STANDARD WIRING

FOR ELECTRIC LIGHT AND POWER

CUSHING

1920

"THE NATIONAL AUTHORITY ON WIRING"

26th YEAR **1920** 26th EDITION

STANDARD WIRING

FOR

ELECTRIC LIGHT AND POWER

AS ADOPTED BY

THE FIRE UNDERWRITERS

OF THE UNITED STATES

IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE, WITH EXPLANATIONS, ILLUSTRATIONS AND TABLES NECESSARY FOR OUTSIDE AND INSIDE WIRING AND CONSTRUCTION FOR ALL SYSTEMS, TOGETHER WITH SPECIAL SECTIONS ON HOUSE WIRING, THEATRE AND MOVING PICTURE HOUSE WIRING, GARAGE WIRING, MARINE WIRING, TECHNICAL TERMS AND THEIR VALUES, AND OTHER USEFUL INFORMATION.

By

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PREFACE

THE Author has made it his aim in compiling the following pages to set forth, as clearly as possible, the essential rules and requirements for safe and efficient inside and outside wiring and construction for electric light, heat and power, to standardize, as much as possible, all work of this nature, and to respectfully suggest to the Electrical Engineer, Architect, Central Station Manager, Contractor and Wireman just what is required by Fire Underwriters' Inspectors throughout the United States.

A practical guide to the man who does the job—How to do it, and where to get the standard apparatus and supplies to do it with.

In the compilation of this edition, most valuable assistance and co-operation has been rendered by Mr. Ralph W. Sweetland, Secretary of the Electrical Committee of the National Fire Protection Association; Mr. Hubert S. Wynkoop, M.E., in charge of electrical inspection for the City of New York; the National Electric Light Association; the Engineering Committee of the Pennsylvania Electric Association and the Society for Electrical Development.

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Inside Wiring

General Suggestions for All Systems and Voltages

Throughout this book the terms, "low-potential," "high-potential" and "extra-high-potential" will appear frequently.

By low-potential, from the fire underwriter's standpoint, is meant any potential of 550 volts or less; high-potential, over 550 and not exceeding 3,500 volts; extra-high-potential, over 3,500 volts. As extra-high-potential systems are permitted only in power stations and sub-stations, and high-potential systems within but comparatively few buildings, and under the most rigid restrictions, this section, with the exception of a few final pages, will deal wholly with low-potential inside wiring and construction.

Service Wires.—Every circuit which enters any building, and furnishes current for light, power and heat from a central station source of supply, should be provided with an approved service switch and cut-out located within the building and at the nearest practicable point to that at which the service wires enter.

Modern practice, which implies "Safety First," is adopting the safety enclosed switch, so called, which consists of a steel box which completely encloses both the service switch and cut-out, and is so constructed that the switch is externally operated, or that when the door of the switch is opened all exposed parts of both the switch and fuse terminals are dead; thus eliminating all danger from shock to the operator when replacing burned-out fuses.

Approved "Rubber-Covered Wire" should be used exclusively in all interior wiring, although the Fire Underwriters allow "slow burning" wire to be used in dry places when wiring is entirely exposed to view and rigidly supported on porcelain or glass insulators. No wire smaller than No. 14 B. & S. gage, except as allowed for fixture work and pendant work should ever be used.

A smaller wire may be amply large electrically but for mechanical strength No. 14 is the minimum size accepted.

The copper conductors before being rubber covered should be thoroughly tinned and the thickness of the

rubber covering should correspond to the following table for voltages up to 600:

From	No.	14 to No.	8	inclusive,	3/64 inch
"	"	7 to "	2	"	1/16 "
"	"	1 to "	0000	"	5/64 "
Over		0000 to	500000 c. m.	"	3/32 "
From		525000 to	1000000 c. m.	"	7/64 "
Larger than			1000000 c. m.	"	1/8 "

For voltages above 600 the rubber covering is correspondingly thicker. All that the contractor and wireman need know about a "rubber covered" wire is that it is of the proper size for the current it is to carry, the thickness of the insulation for the voltage and that it is approved.—"National Electrical Code Standard."

Consult your supply dealer or any of the manufacturers of approved wires and cables, given on pages 431 to 435, who will furnish the proper insulation for the voltage required. Complete specifications for all classes of wire are given on pages 417 to 450.

"Slow-Burning" Wire should have an insulation consisting of three braids of cotton or other thread with the interstices well filled with insulating and fireproofing compound. The outer braid should be designed to resist abrasion and have its surface finished smooth and hard. This class of wire is especially useful in hot, dry places where "rubber covered" wires would perish.

The complete covering should be of a thickness not less than that given in the following table:

From	No.	14 to No.	8	inclusive,	3/64 inch
"	"	7 to "	2	"	1/16 "
"	"	1 to "	0000	"	5/64 "
Over		0000 to	500000 c. m.	"	3/32 "
From		525000 to	1000000 c. m.	"	7/64 "
Larger than			1000000 c. m.	"	1/8 "

"Weatherproof" Wire is for out-door use, where moisture is certain and where fireproof qualities are not so essential. It should have a covering of at least three braids thoroughly impregnated with a dense moisture repellent. The thickness of its insulation should correspond to that of "slow-burning" wire. See page 125.

Carrying Capacity of Wires. The table on page 17 gives the safe carrying capacity of wires from No. 18 B. & S. gage to cables of 2,000,000 circular mils. No wires smaller than No. 14 should be used except for fixture wiring and pendant cords. For fixtures No. 18 may be used.

All wires of the size of No. 8 B. & S. gage or larger when used in connection with knobs should be securely

DOSSERT CONNECTORS

Two-Way, Type A, Showing Detail

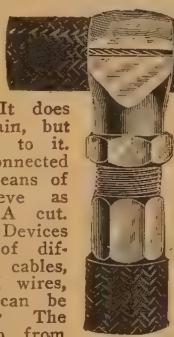
Dossert Connectors eliminate entirely the use of solder in making electrical connections and splices, and are approved for use without solder by the National Board of Fire Underwriters for all classes of wiring.

By their use much labor is saved and splices obtained that will withstand any overload. Many careful tests show that a splice made by means of a Dossert Connector will not heat as much as the cable which it connects when the cable is heavily overloaded.

Type A Connectors are for use on cables, stranded or solid wires, rods and tubing. They are simple and effective, and by their use splices can be quickly made in conductors of any size. Type A Connectors, however, should not be used on a cable that is to be subjected to heavy tensile strains.

Type B Connectors are for use on stranded wires or cables only, and are designed to make a joint which will withstand heavy tensile strains. They are not made for wires smaller than No. 0.

The Cable Tap is used to connect a branch wire, rod, or bleeder to a main wire, rod or feeder. It does not splice the main, but simply clamps on to it. Branch wire is connected to cable tap by means of a nut and sleeve as shown in Type A cut. With Dossert Devices any combination of different sizes of cables, stranded and solid wires, rods and tubing can be connected together The cable tap will tap from any size main to any size branch. Terminal and switchboard lugs, front or back connected; angle and swivel lugs, insulated connectors; two-ways, three-ways, equalizers, cable anchors, reducers, elbows, Y's, service box lugs and plugs, grounding devices and stud connectors for threaded rods and flat strips or blocks made in every necessary size and form for all conceivable connections ranging from No. 14 to 2,500,000 C. M. conductors.



Cable Tap

Send for Catalog Fifteen

Dossert & Company

H. B. LOGAN, President

242 West 41st Street **New York, N. Y.**

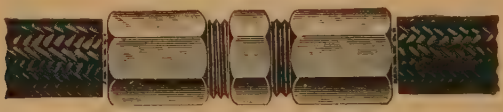
tied thereto with tie wires having of the same type insulation.

Solid porcelain knobs should be used at the end of runs where circuits are terminated. Split knobs or cleats should be used for conductors smaller than No. 8 B. & S. gage, except at the end of runs.

All knobs or cleats should be fastened by screws or nails of generous length. If nails are used they should be long enough to penetrate the woodwork not less than one-half the length of the knob and fully the thickness of the cleat. Washers should be used with both screws and nails to prevent injury to the knobs or cleats.

Splicing should be done so as to make the wires mechanically and electrically secure without solder: then they should be soldered to insure preservation from corrosion and consequent heating from poor contact; then thoroughly taped with good insulating tape.

All joints in wires and cables should be soldered (see "Soldering," unless made with some form of *approved* splicing device.)



Solderless Cable Connector approved for use on stranded wires and cables without the use of solder.

Wiring Table for Direct Current. The following examples show the method of using the table on page 10.

1. What size of wire should we use to run 50 25-watt Mazda lamps, of 110 volts, a distance of 150 feet to the center of distribution with the loss of 2 volts? First multiply the amperes, which will be approximately 11.35 (50-25-watt 110-v. lamps take 11.36 amperes), by the distance, 150 feet, which will equal 1702 ampere feet. Then refer to the columns headed "Actual Volts Lost," and as we are to have only a loss of two volts look down the column headed 2 until you come to the nearest corresponding number to 1702 and we find that 1542 is the nearest number. Put your pencil on the number 1542 and follow that horizontal line to the left until you come to the vertical column headed "Size B. & S.," and you find that a No. 8 B. & S. wire will be the proper size to use in this case.

2. What size wire should we use to carry current for a motor that requires 30 amperes and 220 volts, and is situated 200 feet from the distributing point, the "drop" in volts not to exceed 2 per cent.? First multiply 30 amperes by 200 feet, as we did in the first example, and we get 6000 ampere feet. Now look at the upper left hand corner of the table and you will see a vertical column headed "Volts." Go down this column until you come to 220 and follow the horizontal column to the right until you come to the figure 1.8 which is the nearest we can come to a 2 per cent. loss without a greater loss or "drop." Place your pencil on a figure 1.8 and follow down the vertical column of figures until you come to the nearest corresponding figure of 6000, which we find to be 6200. Then with your pencil on this figure follow the horizontal line to the left and we find that a No. 5 B. & S. wire is a proper size to use for the above conditions.

3. Supposing we have occasion to inspect a piece of wiring, and find a generator operating 50-25-watt 110-volt Mazda lamps at a distance of 150 feet, and our wire gauge shows that wire in use is a No. 12 B. & S., at what loss, or "drop," are these lamps being operated? First multiply the amperes, which will be approximately 11.35 (50-25-watt 110-volt Mazda lamps take 11.36 amperes, by the distance, 150 feet), and we get 1702 ampere feet. As we find in use a No. 12 B. & S. wire we look for the vertical column headed "Size B. & S." and follow it down until we come to 12. With our pencil on the figure 12 we travel along the horizontal line to the right until we come to the nearest corresponding number to 1702, which we find to be 1830. Then starting at this number we travel up the vertical column and we find a loss of about 6 actual volts, or a 5 per cent. loss, which would greatly reduce the candle-power or brilliancy of the lamps. A larger wire should, therefore, be used.

ALTERNATING CURRENT WIRING

Wiring Calculations for Alternating Current. When figuring wire sizes for alternating current, except in cases of long distances, the following methods of calculating should be used.

As compared with the circular milage of each conductor of a two-wire system, that of each conductor

of other systems, transmitting same power with the same distance, volts lost, and lamp voltage is, for:

3 wire, single phase	25.0%
4 wire, single phase	11.1%
4 wire, two phase	50.0%
3 wire, two phase	50.0%
with middle wire	75 %
4 wire, three phase, with neutral	16.6%
3 wire, three phase	50.0%

All wires of each system, except 3 wire two phase, considered of same size.

We will now take an example in each system and show how to calculate the wire size.

Three Phase, Three Wire. What size wire should we use to run 1-220 volt, 30 horsepower induction motor, and light 102-220 volt, 60 watt Mazda lamps, a distance of 400 feet to the center of distribution with the loss of 7 volts?

Let us refer to the table on page 11. Here we see that the amperes per phase (same as amperes per terminal) of a 3 phase, 220 volt, 30 H.P. motor is 81. We must calculate the amperes per phase for the lamps by using this formula:—

$$\text{Amperes} = \frac{\text{total watts of lamps}}{1.73 \times \text{volts}}$$

In this case there are 102-60 watt lamps to be burned at 220 volts, therefore the

$$\text{Amperes per phase for lamps} = \frac{102 \times 60}{1.73 \times 220} = 16$$

Adding this to the 81 amperes for the motor we have $81 + 16 = 97$ for the total amperes per phase. Now let us look at the wiring table for three phase three wire circuits on page 12. It says at the top of this page "multiply current in amperes per phase by single distance (in feet) and refer to the nearest number under column of Actual Volts Lost, to find size of wire." Following these directions:—

$97 \times 400 = 38{,}800$; under column of 7 volts lost, the nearest number is 39,800, and following horizontally to the left, under column headed "Size B. & S." we find that No. 0 wire is our size, and since the allowable carrying capacity is 127 amperes, this size is permissible.

Two Phase, Three Wire. What size wire should we use to run 50-40 watt Mazda lamps and 1-10 H. P. induction motor, 220 volt service, a distance of 100 feet from the center of distribution, with a loss of 3 volts? There will be 25 lamps per phase, and from the table on page 366 we find that the current taken by a 40 watt, 110 volt Mazda lamp is .364 amperes; 25 of these lamps taken $25 \times .1818 = 9.10$ amperes. Referring to the table on page 11 we note that the amperes per phase of a 10 H. P., 220 volt, 2 phase motor is 25. This, then, gives us a total of $25 + 9.10 = 34.10$ amperes per phase.

Turning to page 12 and following the directions given at the top of the table:—

$$34.10 \times 100 = 34.10;$$

under the column of 3 volts loss, we find opposite the nearest number (3690) that we are to use No. 6 wire for the two outside lines and No. 4 wire for the middle one .

Two Phase, Four Wire. For this system of wiring calculate the amperes per phase the same as for 2 phase, three wire, and use the table on page 10 to find the size of wire. In the above problem under 2 phase, three wire, if we were to run a 2 phase, four wire service, we would use No. 6 wire for each line.

Three Phase, Four Wire, with Neutral. This system is very little used and therefore no table is given, but the sizes can be calculated in this way:—Calculate the circular mils necessary for a two wire system of the same total wattage, distance, volts lost and applied voltage and take as size for each wire 16.1%. For example, a system using a total of 10,000 watts, at 220 volts, 500 feet and 10-volt drop, circular mils for two wire system =

$$\frac{10.8 \times 2 \times 500 \times 45.5}{10} = 49{,}000.$$

16.1% of this is $49{,}000 \times .161 = 8{,}170$. From table on page 12 we find that the nearest size (larger) is No. 10 wire, therefore we must use four wires of this size.

Single Phase, Two Wire. Calculate for this the same as for two wire D. C., using the table on page 10. In the case of motors, obtain the amperes required from table on page 11.

WIRING TABLE FOR LIGHT AND POWER.

Two Wire D. C. and Single Phase, A. C., and Four Wire Two Phase A. C.

Multiply current in amperes for D. C. and single phase (or amperes per phase when Two Phase Four Wire) by Single distance in feet and refer to the nearest corresponding number under column of Actual Volts Lost, to find wire size.

Volts.	Percentage of Loss.													
2000	1.2	1.1	1.0	0.75	0.5	0.45	0.4	0.35	0.3	0.25	0.2	0.15	0.1	0.05
1000	2.4	2.2	2.0	1.5	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
500	4.8	4.3	3.9	2.9	2.0	1.8	1.6	1.4	1.2	1.0	0.8	0.6	0.4	0.2
220	10.3	9.3	8.3	6.5	4.4	3.9	3.5	3.1	2.7	2.2	1.8	1.4	0.9	0.45
110	18.5	17.0	15.4	12.0	8.4	7.6	6.8	6.0	5.2	4.4	3.5	2.7	1.8	0.9
52								11.8	10.3	8.8	7.1	5.5	3.7	1.9

Carrying Capacity* Amperes	Size. B. & S.	Actual Volts Lost.												
		25	22.5	20	15	10	9	8	7	6	5	4	3	2	1
225	0000	247000	222300	197600	148200	98800	88920	79040	69160	59280	49400	39520	29640	19760	9880
175	000	196000	176400	156800	117600	78400	70560	62720	54880	47040	39200	31360	23520	15680	7840
150	00	155375	139837	124300	93225	62150	55935	49720	43505	37290	31075	24860	18645	12430	6215
125	0	123250	110925	98600	73950	49300	44370	39440	34510	29580	24650	19720	14790	9860	4930
100	1	97750	87975	78200	58650	39100	35190	31280	27370	23460	19550	15640	11730	7820	3910
90	2	77500	69750	62000	46500	31000	27900	24800	21700	18600	15500	12400	9300	6200	3100
80	3	61500	55350	49200	36900	24600	22140	19680	17220	14760	12300	9840	7380	4920	2460
70	4	48750	43875	39000	29250	19500	17550	15600	13650	11700	9750	7800	5850	3900	1950
55	5	38750	34875	31000	23250	15500	13950	12400	10850	9300	7750	6200	4650	3100	1550
50	6	30750	27675	24600	18450	12300	11070	9840	8610	7380	6150	4920	3690	2460	1230
35	8	19275	17347	15420	11565	7710	6939	6168	5397	4626	3855	3084	2313	1542	771
25	10	12125	10912	9700	7275	4850	4365	3880	3395	2910	2425	1940	1455	970	485
20	12	7625	6862	6100	4575	3050	2745	2440	2135	1830	1525	1220	915	610	305
15	14	4800	4320	3840	2880	1920	1728	1536	1344	1152	960	768	576	384	192

Note.—In case a larger loss than any given in the table is required, proceed as follows: Divide the ampere feet by 10 and then refer to column of Actual Volts Lost divided by 10, from which we find the size of wire as before. For examples worked out to illustrate the use of the above table see pages 6 and 7.

* Rubber insulation. For carrying capacity of weatherproof insulated wires, see table on page 17, fourth column.

APPROXIMATE AMPERES PER TERMINAL FOR ALTERNATING CURRENT INDUCTION MOTORS.

For determining capacity of fuses, setting of circuit breakers, and sizes of wires in connection with tables see index page 435.

H.P. of	110 Volts			220 Volts			440 Volts			550 V.	1100 V.	2200 V.
Motor	1 Phase	2 Phase	3 Phase	1 Phase	2 Phase	3 Phase	1 Phase	2 Phase	3 Phase	3 Phase	3 Phase	3 Phase
½	6.6	3.3	3.7	3.4	1.7	1.8	1.8	.9	1			
1	12	6	6.5	6	3	3.2	3	1.5	1.6			
2	21	10.5	12	19	5	6	5.2	2.6	3	2.5		
3	30	15	17	15	7.5	9	7.5	3.8	4.5	3.5		
5	54	27	30	26	13	15	13	6.5	7.5	6		
7½				40	20	22	20	10	11	9		
10				50	25	29	25	12.5	14	11		
15				71	35	41	36	18	20	16		
20				98	48	55	49	24	27	22		
25				110	54	62	56	27	31	25		
30				150	70	81		35	40	32	16	8
40				198	95	109		47	54	44	21	11
50				230	110	127		55	64	52	27	18
75					165	192		83	96	77	39	20
100					215	248		108	124	100	50	25
150					320	366		160	183	147	80	40
200					410	475		205	237	192	98	49
250					515	590		250	290	237	125	62
300					600	700		300	350	285	150	74

If the motor to be used does not come under this table the amperes per phase can easily be obtained from the manufacturer.

This table allows for power factor and efficiency, and no further calculations are necessary.

WIRING TABLE FOR LIGHT AND POWER—THREE PHASE, THREE WIRE.

For Three Phase, Four Wire, See Page 9.

Multiply current in amperes per phase by single distance and refer to the nearest number under column of Actual Volts Lost, to find size of wire.

B. & S. Carrying Capacity Amperes	Size	Actual Volts Lost.													
		25	22.5	20	15	10	9	8	7	6	5	4	3	2	1
225	0000	286000	256000	227000	171000	114000	102000	91100	80000	68200	57000	45700	34200	22700	11400
175	000	266000	204000	181500	135200	90500	81500	72200	63200	54300	45200	36200	27200	18150	9050
150	00	179200	161300	144000	107000	71800	64300	57200	50200	42800	35800	28700	21600	14400	7180
125	0	142000	128000	113000	85200	57000	51200	45500	39800	34200	28300	22750	17090	11300	5700
100	1	110000	101500	905000	67700	45200	40500	36000	31600	27100	22600	18050	13540	9050	4520
90	2	89500	80800	71800	53700	35800	32300	28700	25000	21400	17900	14300	10800	7180	3580
80	3	71200	64000	56800	42650	28300	25500	22700	19900	17000	14200	11200	8520	5680	2880
70	4	55700	50700	45000	33700	22500	20250	18000	15760	13500	11200	9000	6750	4500	2250
55	5	44700	40200	35800	26800	17900	16100	14300	12360	10600	8950	7150	5370	3580	1790
50	6	35600	31800	28300	21300	14200	12700	11300	9900	8520	7100	5680	4270	2830	1420
35	8	22200	20000	17800	13330	8900	8000	7120	6220	5320	4450	3550	2660	1780	890
25	10	13950	12600	11000	8400	5590	5030	4480	3920	3360	2800	2240	1680	1100	559
20	12	8800	7910	7040	5285	3525	3170	2820	2470	2120	1760	1408	1040	704	352
15	14	5530	4980	4330	3330	2220	1993	1768	1552	1324	1110	886	664	433	222
6	16	3480	3140	2780	2090	1398	1255	1100	978	838	700	558	418	278	140

* Rubber covered; for weatherproof insulated wires, see page 17, fourth column.

WIRING TABLE FOR LIGHT AND POWER—TWO PHASE, THREE WIRE.

For Two Phase, Four Wires, See Page 9.

Multiply current in amperes per phase by single distance and refer to the nearest number under column of Actual Volts Lost to find size of wire.

Capacity Carrying *Amperes Outside Wires	Size B. & S. Outside Wires	Size B. & S. Middle Wire	Actual Volts Lost. 25	22.5	20	15	10	9	8	7	6	5	4	3	2	1
225	0000	300000C.M.	247000	222300	197600	148200	98800	88920	79040	69160	59280	49400	39520	29640	19760	9880
175	000	250000C.M.	196000	176400	156800	117600	78400	70560	62720	54880	47040	39200	31360	23520	15680	7840
150	00	0000	155375	139837	124300	93225	62150	55935	49720	43505	37290	31075	24860	18645	12430	6215
125	0	000	123250	110925	98600	73950	49300	44370	39440	34510	29580	24650	19720	14790	9860	4930
100	1	00	97750	97975	78200	58650	39100	35190	31280	27370	23460	19550	15640	11730	7820	3910
90	2	0	77500	69750	62000	46500	31000	27900	24800	21700	18600	15500	12400	9300	6200	3100
80	3	1	61500	55350	49200	36900	24600	22140	19680	17220	14760	12300	9840	7380	4920	2460
70	4	2	48750	43875	39000	29250	19500	17550	15600	13650	11700	9750	7800	5850	3900	1950
55	5	3	38750	34875	31000	23250	15500	13950	12400	10850	9300	7750	6200	4650	3100	1550
50	6	4	30750	27675	24600	18450	12300	11070	9840	8610	7380	6150	4920	3690	2460	1230
35	8	6	19275	17347	15420	11565	7710	6939	6168	5397	4626	3855	3084	2313	1542	771
25	10	8	12125	10912	9700	7275	4850	4365	3880	3395	2910	2425	1940	1455	970	485
20	12	10	7625	6862	6100	4575	3050	2745	2440	2135	1830	1525	1220	915	610	305
15	14	12	4800	4320	3840	2880	1920	1728	1536	1344	1152	960	768	576	384	192

NOTE.—In case a larger loss than any given in the table is required, proceed as follows:—Divide the ampere feet by 10 and then refer to column of Actual Volts Lost divided by 10, from which we find the size wire as before. For examples worked out to illustrate the use of the above table see pages 6—9.

*Rubber insulation. For carrying capacity of weatherproof insulated wires. See page 17.

Single Phase, Three Wire. Calculate the size necessary for a two wire system of same power, voltage, volts lost, and distance, and take three wires of one-quarter the size thus calculated for this system. (The same general method as given above under Three Phase, Four Wire.)

Single Phase, Four Wire. Calculate the size necessary for a two wire system of same power, voltage, volts lost, and distance, and take 11.1% of the result for each wire in this system. (The same general method as given above under under Three Phase, Four Wire.)

Installation of Wiring

General Suggestions for Inside Work.

All wiring, when not enclosed in approved conduit, moulding or armored cable, should be kept free from contact with gas, water or other metallic piping, or any other conductors or conducting material which it may cross, by some continuous and firmly fixed non-conductor, creating a separation of at least two inches, and in wet places should be arranged so that an air space will be left between conductors and pipes in crossing, and the former should be run in such a way that they cannot come in contact with the pipe accidentally. Where one wire crosses another wire the best and usual means of separating them is by a porcelain tube on one of the wires. The tube should be prevented from moving out of place either by a cleat or knob on each end, or by taping it.

The same method may be adopted where wires pass close to iron pipes, beams, etc.; or, where the wires are above the pipes, as is generally the case, ample protection can frequently be secured by supporting the wires with a porcelain cleat placed as nearly above the pipe as possible.

Wires should be run over rather than under pipes upon which moisture is likely to gather, or which by leaking might cause trouble on a circuit. No smaller size than No. 14 B. & S. gage should ever be used for any lighting or power work; not that it may not be electrically large enough but on account of its mechanical weakness and liability to be stretched or broken in the ordinary course of usage. Smaller wire may be used for fixture work, if provided with approved rubber insulation.

A Device For Every Use

G-E RELIABLE WIRING DEVICES

MADE BY

GENERAL ELECTRIC COMPANY

ATTACHING PLUGS
ENCLOSED FUSES
ENCLOSED FUSE CUTOUTS
FLUSH SWITCHES
LEVER SWITCHES
PLUG FUSES
PLUG CUTOUTS
PORCELAIN SPECIALTIES
ROSETTES
RECEPTACLES
SOCKETS
SNAP SWITCHES
SHADE HOLDERS
SEPARABLE RECEPTACLES

SOLD BY DISTRIBUTORS IN ALL LARGE CITIES

6674

Wires should never be laid in or come in contact with plaster, cement or any finish, and should never be fastened by staples, even temporarily, but always supported on porcelain or glass insulators or cleats which will separate the wires at least one-half inch from the surface wired over and keep the wires not less than two and one-half inches apart. This style of wiring is intended for low potential systems (550 volts or less), and when it is all open work and in dry places, rubber covered wire is not necessary as "Slow-Burning" wire may be used. Wires should not be fished between floors, walls or partitions or in concealed places.

Twin wires should never be used, except in metal conduits or metal raceways (see pages 117 to 127), or when flexible conductors are necessary.

CURRENT REQUIRED TO FUSE WIRES OF COPPER AND IRON.

No. B. & S. Gage	Copper Amperes	Iron Amperes	No. B. & S. Gage	Copper Amperes	Iron Amperes
10	333.	101.	26	20.6	6.23
11	284.	86.	27	17.7	5.34
12	235.	71.2	28	14.7	4.45
13	200.	63.	29	12.5	3.79
14	166.	50.2	30	10.25	3.11
15	139.	42.1	31	8.75	2.65
16	117.	35.5	32	7.26	2.2
17	99.	32.6	33	6.19	1.88
18	82.8	25.1	34	5.13	1.55
19	66.7	20.2	35	4.37	1.33
20	58.3	17.7	36	3.62	1.09
21	49.3	14.9	37	3.03	.93
22	41.3	12.5	38	2.55	.77
23	34.5	10.9	39	2.20	.67
24	28.9	8.76	40	1.86	.56
25	24.6	7.46			

All wiring should be protected on side walls from mechanical injury. This may be done by putting a substantial boxing about the wires, allowing an air space of one inch around the conductors, closed at the top (the wire passing through bushed holes) and the boxing extending about five feet above the floor. Sections of metal conduit may be used (the wire being protected by approved flexible tubing extending in a continuous length from the lower support of the wire to the upper), and in most cases this practice is preferable. All bushings should be made of non-combustible, non-absorptive insulating material such as glass or porcelain and should be used wherever wires go

CARRYING CAPACITIES AND DIMENSIONS OF WIRES AND CABLES.

As adopted by the National Board of Fire Underwriters of the United States.

For further dimensions of bare and insulated wires, see Index.

Gage No. B. & S.	Diameter Mils	Area Circular Mils	No. Amperes Weatherproof Insulation	No. Amperes Rubber Covered	Ohms Per 1000 Ft. (68° F.)	Lbs. Per 1000 Feet Bare	Feet Per Lb. Bare
18.....	40	1 624	5	3	6.385	4.9	203.40
16.....	51	2 583	10	6	4.016	7.8	127.90
14.....	64	4 107	20	15	2.525	12.4	80.44
12.....	81	6 530	25	20	1.588	19.7	50.59
10.....	102	10 380	30	25	.999	31.4	31.82
8.....	128	16 510	50	35	.628	49.9	20.01
6.....	162	26 250	70	50	.395	79.4	12.58
5.....	182	33 100	80	55	.313	100.2	9.98
4.....	204	41 740	90	70	.248	126.4	7.91
3.....	229	52 630	100	80	.197	159.3	6.27
2.....	258	66 370	125	90	.156	200.9	4.97
1.....	289	83 690	150	100	.124	253.3	3.94
0.....	325	105 500	200	125	.098	319.5	3.13
00.....	365	133 100	225	150	.077	402.8	2.48
000.....	410	167 800	275	175	.062	507.9	1.96
0000.....	460	211 600	325	225	.049	640.9	1.56
Cables...	450	200 000	300	200	.0532	800	
" ...	630	300 000	400	275	.0335	932	
" ...	727	400 000	500	325	.0251	1242	
" ...	814	500 000	600	400	.0201	1553	
" ...	892	600 000	680	450	.0166	1863	
" ...	964	700 000	760	500	.0143	2174	
" ...	1030	800 000	840	550	.0125	2474	
" ...	1092	900 000	920	600	.0111	2795	
" ...	1152	1 000 000	1000	650	.0100	3106	
" ...	1209	1 100 000	1080	690	.0091	3416	
" ...	1263	1 200 000	1150	730	.0083	3727	
" ...	1314	1 300 000	1220	770	.0076	4038	
" ...	1364	1 400 000	1290	810	.0071	4348	
" ...	1413	1 500 000	1360	850	.0066	4658	
" ...	1459	1 600 000	1430	890	.0062	4968	
" ...	1504	1 700 000	1490	930	.0058	5278	
" ...	1548	1 800 000	1550	970	.0055	5588	
" ...	1572	1 900 000	1610	1010	.0052	5898	
" ...	1630	2 000 000	1670	1050	.0050	6208	

For weights of insulated wires, see pages 205-209.

The lower current carrying limit (fifth column) is specified for rubber-covered wires to prevent gradual deterioration of the high insulations by the heat of the wires, but not from fear of igniting the insulation.

The carrying capacity of Nos. 18 and 16 B. & S. gage wire is given, but no smaller than No. 14 should be used for general wiring purposes. Insulated aluminum wire has 84% of the carrying capacities given above.

through walls, floors, timbers or partitions. They should be long enough to bush the entire length of the hole in one continuous piece, or else the hole must first be bushed by a continuous waterproof tube. This tube may be a conductor, such as iron pipe, but in that case the wire should be protected by a continuous length of **approved** flexible tubing extending one inch from each end of the pipe or conduit or far enough to keep the wire absolutely out of contact with the pipe.

If iron pipes, conduits, or metal raceways are used with alternating currents, the two or more wires of the circuit should always be placed in the same conduit.

When crossing floor timbers in cellars or in rooms where they might be exposed to injury, wires should be attached, by their insulating supports, to the under side of wooden strips not less than one-half inch in thickness and not less than three inches wide.

When wires are run immediately under roofs, or in proximity to water tanks or pipes they will be considered as exposed to moisture and care should be taken as described on pages 21 and 22.

The installation of electrical conductors in raceways, or on insulators, in elevator shafts will not be approved, but conductors may be installed in such shafts if encased in **approved** metal conduits (see page 64) or armored cables (see page 62).

In three wire (not three phase) systems, the neutral should be of sufficient capacity to carry the maximum current to which it may be subjected.

Underground Conductors. All underground conductors should be protected against moisture and mechanical injury where brought into a building and all combustible material should be kept from the immediate vicinity.

They should not be so arranged as to shunt the current through a building around any catch-box.

Where underground service enters building through tubes, the tubes should be tightly closed at outlets with asphaltum or other non-conductor, to prevent gases from entering the building through such channels.

No underground service from a subway to a building, and no service from private generating plants should supply more than one building, except by special permission, unless the conductors are properly protected by fuses and are carried outside all the buildings but the ones served. Conductors in conduit or duct under two inches of concrete under a building, or buried

back of two inches of concrete or brick within a wall are considered as lying outside the building. These suggestions do not apply to factory yards and factory buildings under single occupancy or management.

Switches, Cut-Outs and Circuit-Breakers

On constant potential circuits, all service switches and all switches controlling circuits supplying current to motors or heating devices, and all fuses should be so arranged that the fuses will protect and the opening of the switch will disconnect all of the wires; that is, in the two wire system the two wires, and in the three wire system the three wires, should be protected by the fuses and disconnected by the operation of the switch.

The above ruling applies to the installation of exposed or separate switches and cut-outs. Modern practice, however, is rapidly adopting the safety enclosed switch, consisting of a steel box which completely encloses both the switch and its cut-out. Such safety switches, when the door of the box is closed, may be externally operated by a handle. The door may be opened only when the switch is open, and in some types only when all exposed parts of the switch and cut-out block are dead.

When installed without other automatic overload protective devices, automatic overload circuit breakers should have the poles and trip coils so arranged as to afford complete protection against overloads and short circuits. In two or three phase three wire circuits and two phase four wire circuits there should be a trip-coil in each of two phases, and in four wire three phase circuits there should be a trip-coil in each phase. If a circuit breaker is also used in place of the switch it should be so arranged that no one pole can be opened manually without disconnecting all the wires.

This, of course, does not apply to the grounded circuit of street railway systems.

They should not be placed where exposed to mechanical injury nor in the immediate vicinity of easily ignitible stuff or where exposed to inflammable gases or dust or to flyings of combustible material.

Where the occupancy of a building is such that switches, cut-outs, etc., cannot be located so as not to be exposed as above, they should be enclosed in approved dust-proof cabinets with self-closing doors, except oil switches and circuit breakers which have dust-tight casings.

Cabinets and cut-out boxes should be of metal when used with metal conduit, armored cable or metal raceway systems (see page 174).

They should also, when exposed to dampness, be enclosed in a moisture-proof box. The cover of the box should be so made that no moisture which may collect on the top or sides of the box can enter it.

Time switches, sign flashers and similar appliances should be of approved design and enclosed in approved cabinets.

Series Arc Lamp Wiring. All wiring in buildings for constant current series arc lighting should be with approved rubber covered wire and the circuit arranged to enter and leave the building through an approved double contact service switch, which means a switch, mounted on a non-combustible, non-absorptive insulating base, capable of closing the main circuit and disconnecting the branch wires when turned "off." This switch should be so constructed that it will be automatic in action, not stopping between points when started, and must prevent an arc between points under all circumstances, and should indicate, upon inspection, whether the current be "on" or "off." Such a switch is necessary to cut the high voltage current completely out of the building in case of fire or when it becomes necessary to make any changes in the lamps or wiring. It should be in a non-combustible case.

This class of wiring should never be concealed or encased except when required by the Electrical Inspector, and should always be rigidly supported on porcelain or glass insulators which will separate the wiring at least one inch from the surface wired over, and the wires should be kept at least eight inches from each other, except within the structure of lamps, or hanger-boards or in cut-out boxes or such fixtures when a less distance is necessary. This class of wiring should, on side walls, be protected from mechanical injury by a substantial boxing, retaining an air space of at least one inch around the conductors, closed at the top (the wires passing through bushed holes), and extending not less than seven feet from the floor. When crossing floor timbers in cellars, or in rooms where they might be exposed to injury, wires should be attached by their insulating supports to the under side of a wooden strip not less than one-half an inch in thickness. Instead of the running-boards, guard strips on each side of and close to the wires will be sufficient. These strips should be not less than seven-

eighths of an inch in thickness and at least as high as the insulators.

Except on joisted ceiling, a strip one-half of an inch thick is not considered sufficiently stiff and strong. For spans of say eight or ten feet, where there is but little vibration, one-inch stock is generally sufficiently stiff; but where the span is longer than this or there is considerable vibration, still heavier stock should be used.

Series arc lamps, now rapidly going out of use, being replaced by gas filled high efficiency mazda or tungsten lamps, should be isolated from inflammable material, and should be provided at all times with a glass globe surrounding the arc, and securely fastened upon a closed base. Broken or cracked globes should not be used.

They should be provided with a wire netting (having a mesh not exceeding one and one-fourth inches) around the globe, and an **approved** spark arrester when readily inflammable material is in the vicinity of the lamps, to prevent escape of sparks of carbon or melted copper. It is recommended that plain carbons, not copper-plated, be used for lamps in such places.

Outside arc lamps should be suspended at least eight feet above sidewalks. Inside arc lamps should be placed out of reach or suitably protected.

Arc lamps, when used in places where they are exposed to flyings or easily inflammable material, should have the carbons enclosed completely in a tight globe in such manner as to avoid the necessity for spark arresters.

"Enclosed arc" lamps, having tight inner globes, may be used in such places.

Series Incandescent Lamp Wiring

The same suggestions given for the wiring for series arc lamps should apply to this class of work as well. Each series incandescent lamp should be provided with its own automatic cut-out. Each lamp should be suspended from a hanger-board by a rigid tube.

In no way should they come in contact with, or be connected to, gas fixtures. No electro-magnetic device for switches and no multiple-series or series-multiple systems of lighting should be used.

Wiring in Damp Places

Special wiring for damp places, such as breweries, packing houses, stables, dye houses, paper or pulp mills, storage battery rooms, or buildings specially liable to moisture or acid or other fumes liable to injure the wires or their insulation, except where used

for pendants, should always be done with approved rubber covered or weather-proof wire, and rigidly supported on porcelain or glass insulators which separate the wires at least one inch from the surface wired over and should be kept apart at least two and one-half inches for voltages up to 300 and four inches apart for higher voltages. The wire in such damp places should contain no splices as it is almost impossible to tape a splice so as to prevent acid fumes from getting at the copper surface.

Service Switches and Cut-Outs

On constant potential systems the general rules, for all voltages, require that a circuit-breaker, switch and fuse, or better still, a safety enclosed switch and cut-out within its own steel box, be placed on all service wires, either overhead or underground, in the nearest accessible place to the point where they enter the building and inside the walls, and arranged to cut off the entire current from the building. Departure from this rule may be authorized only under special permission in writing.

Where the switch required on all service wires is inside the building, the cut-out (circuit-breaker or fuse) is usually placed so as to protect it, unless the switch is of the safety enclosed type and is contained in an approved steel box, under which condition the switch may be placed between the source of the supply and the cut-out. See illustration on page 96.

Modern practice is demanding the exclusive use of the "safety enclosed switch" and its cut-out. These safety switches, of which there are now many excellent types on the market, consist of steel boxes, containing the service switch and cut-out, and so constructed that they are perfectly safe to operate by an external handle. Upon opening the door of some types of safety enclosed switch every exposed part of the switch and fuse terminals become dead, and the renewal of fuses is accomplished with no danger of shock to the operator, and only upon closing the door of the switch box can the switch be closed.

Cut-outs should never be placed in any permanently grounded service wire, except in the two wire branch circuits, where both wires are required to be fused.

In risks having private plants, the yard wires running from building to building are not considered as service wires, so that cut-outs would not be required where the wires enter buildings, provided that the next fuse back

is small enough to properly protect the wires ins. the building in question.

Cut-outs (fuses) should be placed at every point where a change is made in the size of wire unless the cut-out in the larger wire will protect the smaller.

Cut-outs should be in plain sight, unless enclosed in an **approved** cabinet, and readily accessible. They should not be placed in the canopies or shells of fixtures.

Link fuses may be used only when mounted on **approved** bases which, except on switchboards should be mounted in **approved** cut-out boxes, or cabinets. A space of at least two inches should be provided between the open-link fuses and metal lined walls or metal, metal lined or glass paneled doors of cabinets or cut-out boxes.

Cut-outs should be so placed that no set of small motors, small heating devices or incandescent lamps, whether grouped on one fixture or on several fixtures or pendants (nor more than 16 medium size or 25 candelabra size sockets or lamp receptacles) requiring more than 660 watts, will be dependent upon one cut-out.

By special permission, in cases where wiring equal in size and insulation to No. 14 B. & S. gage **approved** rubber-covered wire is carried direct into keyless sockets or receptacles, and where the location of sockets and receptacles is such as to render unlikely the attachment of flexible cords thereto, the circuits may be so arranged that not more than 1,320 watts (or thrity-two sockets or receptacles will be dependent upon the final cut-out.

Except for signs and outline lighting, sockets and lamp receptacles will be considered as requiring not less than 40 watts each, if of the medium size, or 25 watts each, if of candelabra size.

Receptacles for attachment plugs rated at not over 660 watts each may be connected to ordinary branch circuits, and when so installed will be considered as requiring not less than 40 watts. Heating and other appliances (see page 94) rated not over 660 watts each may be connected to such receptacles only when the normal load in use on the circuit at any time will not exceed 660 watts. A cut-out should be provided for each receptacle rated above 660 watts.

All branches or taps from any three-wire system which are directly connected to lamp sockets or other translating devices, should be run as two-wire circuits.

All wires of all branch or tap circuits which are directly connected to lamp sockets or other translating devices should be protected by proper fuses.

The fuses in the branch cut-outs protecting circuits of 660 watts or less shall not have a rated capacity greater than 10 amperes for 125 volts or less, or than 6 amperes for from 126 to 250 volts.

When 1,320 watts are dependent upon one fusible cut-out, as is allowed in theatre lighting, outline lighting, signs and large chandeliers, the fuses may be in accordance with the following table:

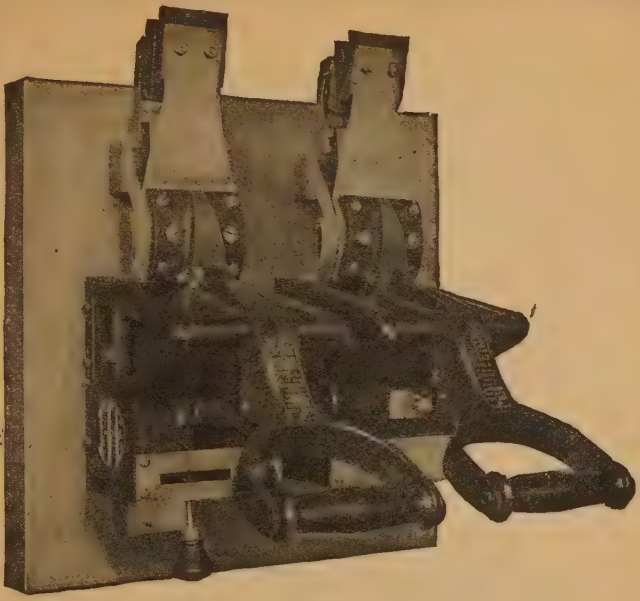
125 volts or less.....20 amperes
126 to 250 volts.....10 amperes

Fused rosettes may be used only for open work in large mills. **Approved** link fused rosettes may be used at a voltage of not over 125 and **approved** enclosed fused rosettes at a voltage of not over 250, the fuse in the rosette not to exceed 3 amperes, and a fuse of over 25 amperes should not be used in the branch circuit. Fused rosettes are not permitted in New York or Chicago.

The rated capacity of fuses (see pp. 163 and 164) should not exceed the allowable carrying capacity of the wire as given in the table on page 17. Circuit-breakers should not be set more than 30 per cent. above allowable carrying capacity of the wire, unless a fusible cut-out is also installed on the circuit. Where a rubber-covered conductor carries the current of only one A. C. motor of a type requiring large starting current, it may be protected by a fuse or an automatic circuit breaker without time limit device, rated in accordance with Table B. The rated continuous current capacity of a time limit circuit breaker protecting a motor of the above type need not be greater than 110 per cent. of the motor current rating, provided the time limit device is capable of preventing the breaker opening during the starting period. New York and Chicago require the capacity of the circuit-breaker to be 125 per cent.

In the great majority of cases where A. C. motors of the above type are started by means of autostarters the current-carrying capacity of wires meeting the rule will not exceed the following percentages of the full load current of the motors:—

Rated full load current	Percentage
0- 30 amperes	250
Above 30 amperes	200



I-T-E

Circuit Breakers

for every service

The next time a fuse blows replace it with an I-T-E Circuit Breaker.

The Cutter Co.

PHILADELPHIA

For the protection of wires having safe carrying capacities exceeding the rated capacity of the largest **approved** enclosed type fuses, **approved** enclosed fuses, arranged in multiple, may be used, provided as few fuses as possible are used and the fuses are of equal capacity, and provided the cut-out terminals are mounted on a single continuous pair of substantial bus bars. The total capacity of the fuses should not exceed the safe carrying capacity of the wires. This does not apply to motor circuits.

Fixture wire or flexible cord (see page 125) of No. 18 B. & S. gage will be considered as properly protected by fuses not exceeding 10 amperes.

Each conductor of motor circuits, except on main switchboard or when otherwise subject to competent supervision, should be protected by an **approved** fuse, whether automatic overload circuit-breakers are installed or not (see page 159). Single phase motors may have one side protected by an **approved** automatic overload circuit-breaker only, if the other side is protected by an **approved** fuse.

Circuit-breakers alone will be approved only for circuits having a maximum capacity greater than that for which approved enclosed fuses are rated (see page 24).

Circuit -Breakers. All circuit-breakers, for voltages of 550 or less, should be mounted on non-combustible, non-absorptive, insulating bases, such as slate or marble. Bases with an area of over twenty-five square inches should have at least four supporting screws. Holes for the supporting screws should be so located or countersunk that there will be at least one-half of an inch space measured over the surface between the head of the screw or washer and the nearest live metal part, and in all cases when between parts of opposite polarity should be **countersunk.**

They should be plainly marked with the name of the maker and the current and voltage for which they are designed.

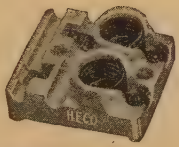
Cut-Outs. All small safety devices which, under this heading, mean fuses of the open link or enclosed or cartridge type, should be supported on bases of non-combustible, non-absorptive, insulating material.

Cut-outs should be of the enclosed type, when not arranged in **approved** cabinets, so as to obviate any danger of the melted fuse metal coming in contact with any substance which might be ignited thereby.

Cut-outs should operate successfully on short-circuits, under the most severe conditions with which they

Plug-Cutouts
Entrance-Switches
Panel-Cutouts
N. E. C.-Cutouts

No. 1935



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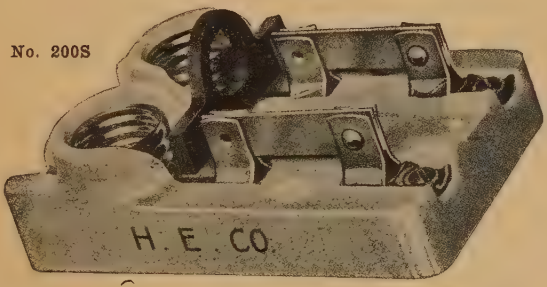


Manufactured by

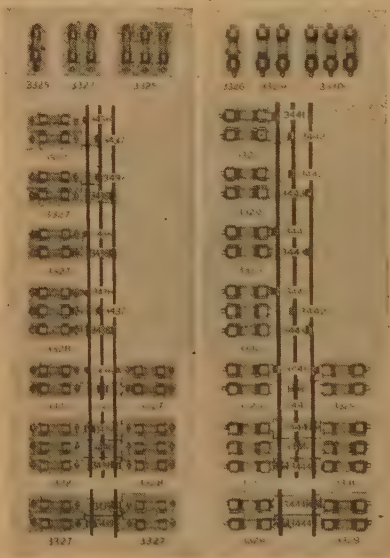
HEINEMANN ELECTRIC CO.

Philadelphia, Pa.

NOARK INTERCHANGEABLE MAIN LINE and BRANCH CUTOUT BASES

With only the fittings here shown

in addition to their use as Main-line Cutout Bases, you can assemble any of the seven Branch Cutout Bases illustrated.



Think of the 35 per cent reduction in your stock which this scheme permits and then grasp the possibilities from the wireman's point of view.

With a few Branch Tap Straps and Main-line Cutout Bases in his grip, he can go out to a job and meet every condition as it arises.

This system of interchangeable Main-line and Branch Cutout Bases is approved by the Underwriters' Laboratories, Inc.

H. W. Johns-Manville Co.
NEW YORK CITY
10 Factories—Branches in 63 Large Cities

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THE JOHNS-PRATT COMPANY HARTFORD, CONN.
H.W. JOHNS-MANVILLE CO.
SOLE SELLING AGENTS

are liable to meet in practice, at 25 per cent. above their rated voltage, and for link fuse cut-outs with fuses rated at 50 per cent. above the current for which the cut-out is designed, and for enclosed fuse cut-outs with the largest fuses for which the cut-out is designed.

With link fuse cut-outs there is always the possibility of a larger fuse being put into the cut-out than it was designed for, which is not so easily done when National Electrical Code (N. E. C.) standard enclosed fuses are used. Again, the voltage in most plants can, under some conditions, rise considerably above the normal. The need of some margin, as a factor of safety to prevent the cut-outs from being unnecessarily blown out in ordinary service, is therefore evident as given in the preceding paragraph.

The most severe service which can be required of a cut-out in practice is to open a "dead short-circuit," with only one fuse blowing.

Every enclosed fuse should be marked where it will be plainly visible when installed with the name of the maker, and current and voltage for which it is designed.

Link Fuse Cut-Outs. The following suggestions are intended to cover open link fuses mounted on slate or marble bases, including switchboards, tablet-boards and single fuse-blocks. They do not apply to the ordinary porcelain cut-out blocks, enclosed fuses, or any special or covered type of fuse. When tablet-boards or single fuse-blocks with such open link fuses on them are used in general wiring, they should be enclosed in cabinet boxes made to meet the requirements. This is necessary, because a severe flash may occur when such fuses melt, so that they would be dangerous if exposed in the neighborhood of any combustible material.

Such cut-outs should be mounted on bases made of strong non-combustible, non-absorptive, insulating material. The design of the base should be such that, considering the material used, the base will withstand the most severe conditions liable to be met in practice. Bases with an area of over twenty-five square inches should have at least four supporting screws. Holes for supporting screws should be kept outside of the area included by the outside edges of the fuse terminals, and should be so located or countersunk that there will be at least one-half inch space, measured over the surface, between the head of the screw or washer and the nearest live metal part.

The following spacings should be attended to for this class of fuses:

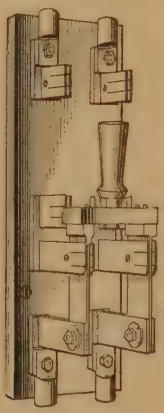
Not over 125 Volts:

	Minimum Separation of Nearest Metal Parts of Opposite Polarity.	Minimum Break-Distance.
10 amperes or less.	¾ inch	¾ inch
11- 100 amperes.....	1 "	¾ "
101- 300 "	1 "	1 "
301-1,000 "	1¼ "	1¼ "

Not over 250 volts:

10 amperes or less.	1½ inch	1¼ inch
11- 100 amperes.....	1¾ "	1¼ "
101- 300 "	2 "	1½ "
301-1,000 "	2½ "	2 "

The link fuses used in this class of cut-out, should all have contact surfaces or tips of copper, or other hard metal, securely soldered to the fuse wire.



An Approved Double Pole Knife Switch, Showing Terminals for Approved Enclosed Fuses of the Knife Blade Type. Always install so that the handle will be *up* when circuit is closed.

Although the preceding paragraphs show how open link fuses may be installed, modern practice has practically eliminated the link fuse and substituted the enclosed or cartridge type fuse in every class of wiring. For heavy currents, or high voltages, beyond the present enclosed fuse capacities (see pages 40 to 41), the automatic overload circuit-breaker or oil break cut-outs are recommended.

Service Switches

All service wires, either overhead or underground, should be controlled by a service switch and cut-out in the nearest readily accessible place to the point where the wires enter the building, and be arranged to cut off the entire current from all devices, including meters.

Service switches should indicate plainly whether they are open or closed (on or off).

Where service switch, service fuses and meter are combined in an approved self-contained device or compact combination of such devices having no exposed wiring or live parts and no parts unprotected by fuses, except potential coils of the meter, such potential coils may be connected on the supply side of the service fuses.

In risks having private plants the yard wires running from building to building are not considered as service wires, so that switches would not be required in each building if there are other switches conveniently located on the mains or if the generators are near at hand.

All switches should be placed in dry, accessible places, and be grouped as far as possible. All knife switches should be so placed that gravity will not tend to close them (see cut, page 30). Double-throw knife switches should be mounted so that the throw will be horizontal, but if the throw be vertical a locking device should be provided, so constructed as to insure the blades remaining in the open position when so set.

Safety Inclosed Service Switches

While the old fashioned exposed knife switch, when properly constructed and installed, is still permitted by the underwriters for service or entrance purposes, modern practice, as it has been said in several other places in this edition of Standard Wiring, is demanding the use of the safety enclosed and externally operated switch. In fact, many localities are now requiring their use.

Just what are the elements of danger connected with the open switch? First thought suggests only electrical shocks, but an analysis shows us that there are

five separate and distinct dangers which may be enumerated as follows:

1. Electrical shocks.
2. Electric burn from contact.
3. Flash burn from arc.
4. Accidental closing of circuit.
5. Fire resulting from arc or flash.

The first three items concern personal, the last property and the fourth both personal and property dangers.

Conditions and circumstances determine the results of a shock very nearly, if not quite, as much as the potential. One person may come in contact with a 440-volt or 600-volt conductor and suffer no ill effect other than slight momentary pain. Another may get his hands across a 110-volt circuit and be shocked to death. The condition of one's heart or nervous system, moisture on the hands, standing in damp places or on grounded metal, are all factors to be considered. An arm-to-arm contact where the current transverses vital organs is more dangerous than a foot-to-foot contact. It is therefore wrong to assume that only high potentials are dangerous and that on low voltage open switches do not represent any particular hazard.

Even where conditions or the nature of the installation are such that serious danger from the low voltage need not be apprehended, there is always another factor to be reckoned with. This is the ever-present possibility, due to leakage or crosses, of voltages higher than the normal operating voltage being imposed upon the circuit. In such cases there is nothing in the appearance of the conductor, whether this be a wire or switch blade, to indicate the higher voltage, and if proper safeguards have not been provided disastrous results may follow.

Carelessness or improper handling is, of course, the most prolific cause of burns from the open switch. Through constant use many people come to regard a switch in the same light as the valve in a steam or water pipe—something which can be operated carelessly or indifferently without any regard for consequences. This may be continued for a time without serious results, which merely serves to encourage the operator's contempt of a lurking danger. But some day the unexpected will happen. An unusually heavy load or a surge in the line will cause an arc or flash, and the hospital opens its doors to receive another case.

A very important feature of many of the safety

CONDULETS

TYPE M F C
Safety-First Motor Starting Switch Condulet

Protect the Operator

Avoid the dangerous open knife switches in your installation by using Crouse-Hinds safety-first switch condulets.

A Complete catalogue sent upon request

TYPE M K C
Safety-First Line Switch

TYPE Z Y B
Safety-First Combination Switch and Cut-Out

CONDULET THE JOB

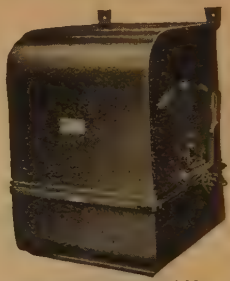
CROUSE-HINDS COMPANY

SYRACUSE, N. Y., U. S. A.

BOSTON NEW YORK CHICAGO

CROUSE-HINDS

Bulletin No. 2111
D. C. Enclosed Starter



Bulletin No. 9141
Starting Compensator

THREE POPULAR STARTERS

Bulletin 2111 is a totally enclosed hand starter for direct current motors. Low voltage protection, knock-out holes for conduit wiring, complete protection to workman and an easily disassembled case are salient features.

Bulletin 9141 Auto Transformer Starter for polyphase squirrel cage motors is equipped with a duplex time limit overload relay which will not permit a harmful overload to be maintained. Easily renewable and accessible contacts, low voltage protection and liberal construction increase the popularity of this starter.

Bulletin 9118, for polyphase squirrel cage motors, connects the motor ahead of the fuses with resistance in each phase for starting and then engages the fuses and cuts out the resistance when the motor has attained speed. Bulletin 9116 is similar but without starting resistance as it is used with motors which can be thrown directly across the line. Low voltage protection is standard with both.

Bulletin No. 9118
Enclosed Starter for
Small A. C. Motors

Descriptive Literature on Request

The Cutler Hammer Mfg. Co.
Works: Milwaukee & New York
New York, Boston, Philadelphia, Pittsburgh, Chicago, Cleveland, Detroit, Cincinnati

A single accident will probably cost far more than a complete installation of safety switches. Statistics prove that accidents, due to old style exposed switches, continue to happen in increasing numbers and emphasize the urgent need of safer electrical installations.

Square D
Safety Switches

effectively eliminate both the fire and accident hazard at the point of control. All live parts are completely enclosed in a steel case and switch is operated by a handle outside of box. Cover can be locked or sealed shut and switch may be locked "off." Made in 2, 3 and 4 pole types in 125, 250, 500 a. c. and 600 volts; in capacities from 30 to 1200 amperes. Over 300 different types and sizes permit standardization of equipment. Listed as standard for fire and accident prevention by the Underwriters Laboratories. Meet the requirements of the National Electrical Safety Code. Sold by all leading jobbers and dealers.

Write for Catalogue

SQUARE D COMPANY

Detroit, Michigan

ENTRANCE SWITCHES

SIMPLE AND SAFE
IT'S THE "CIRCLE T"

"FIFTY-SEVEN FORTY-ONE"

EXTERNALLY OPERATED ENTRANCE SWITCH
QUICK BREAK

When box is open the overlap rests on top of box. Cover stays open eliminating the necessity for holding it open when working on switch.

Can be locked open

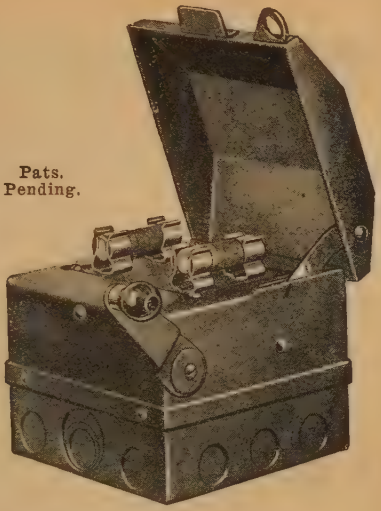
Write for Bulletin

THE TRUMBULL ELECTRIC MFG. CO.
PLAINVILLE, CONN.

100% Safe to Use
100% Safe to Fuse

The MASON SAFETY SWITCH

Pats. Pending.



Complies with the Underwriters Laboratories' "AA" Safety Switch Classification

You **CAN'T** touch live parts with door open,
You **CAN'T** open door with switch closed,
You **CAN'T** close switch with door open,
You **CAN'T** connect line to wrong end,
You **DON'T** fumble among charged clips in replacing fuses.

The Mason Safety Switch is very compact—half to a quarter the size of the enclosed knife switch of equal capacity.

May be used for concealed work. Lower section quickly detachable and adapted to be mounted flush. Upper section, containing switch mechanism, may later be instantly locked into position.

Quick Break **Positive Make** **Perfect**

Made in all capacities to 600 amp. and in 30 and 60 ampere motor starting type.

Sole licensees under Mason Patents

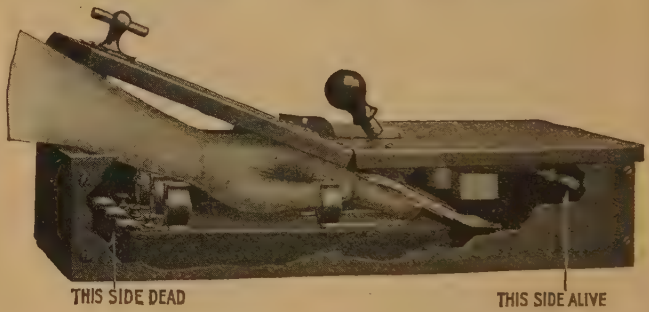
THE TRUMBULL-VANDERPOEL ELECTRIC MANUFACTURING CO.

INCORPORATED

BANTAM **CONNECTICUT, U. S. A.**

Westinghouse-Krantz

Safety Switches, Motor Starters, Panel Boards and Floor Boxes



Impossible to touch live parts

Krantz Safety Enclosed Auto-Lock Brush Switches

Extra-heavy, sheet-steel cases make these switches especially fitted for industrial service. Approved by Underwriters under Classification A, meaning "full safety". Brush-type contacts used.

Krantz Safety Panel Boards

Can be operated safely by any one. Particularly adapted for the control of lighting circuits in Private Houses, Apartment Houses, Hotels, Stores, Factories, etc. Standard live face panel boards also supplied.

Krantz Floor Boxes

For Floor, Wall or Ceiling conduit outlet boxes. Provide a durable, hard and smooth surface for conduit outlets.

All Approved by Underwriters Laboratories.

Westinghouse Electric & Manufacturing Co.

East Pittsburgh, Pa.

switches on the market is that which permits locking the switch in the open position. When repairs become necessary on a machine controlled by such a switch, the workman assigned to the task can lock the switch in the open position by means of a padlock, thereby guarding against the possibility of others carelessly or accidentally closing the switch and starting the machinery. An accident which emphasizes the extreme importance of this lock-off feature happened some time ago in a newspaper plant where three men were underneath a large high speed cylinder press, adjusting or repairing the roll. A boy passing through the plant closed the switch, which was within easy reach and, as presses of this type accelerate rapidly, there was no chance for the workmen to escape. Before the machine could be stopped one of them was crushed to death in the moving parts of the press and the other two badly injured. Had a safety switch with a lock-off feature been used this accident would have been averted.

Under the head of fires or property loss due to the open switch may be suggested the possibility of flashes, resulting from improper operation of the switch, short circuits, blowing out of fuses, etc.

The place to prevent accidents, as well as fires, is at the source. Educating the worker to the principle of safety must accomplish a great deal, but as long as the human element is involved nothing short of approved mechanical safeguards will prevent accidents. Education is a long and tedious process and cannot be expected to show immediate results. That enclosed, externally operated switches occupy a very important place in safety work and should receive the fullest recognition from authorities is evidenced by the fact that the larger industrial concerns of the country which have well organized Safety and Welfare Departments have, almost without exception, adopted enclosed safety switches as standard equipment using them not only in all new installations, but also to replace the open knife switches once installed. Several states and many cities and municipalities have passed rules which bar open knife switches, except on switchboards, and make the use of safety switches compulsory. In the Province of Ontario the use of the open knife switch is no longer permissible under the rules of the Hydro-Electric Power Commission; and a would-be subscriber who attempts to use open knife switches cannot obtain a service connection from the power or lighting company.

Accident statistics prepared by the Fire Prevention Committee of National Electric Light Association shows a percentage of accidents due to accidental contact with electricity and a resulting time loss and compensation cost that is appalling. Until such time as the use of enclosed safety switches becomes universally compulsory these accidents will continue to happen and will represent a hindrance to the development of the electrical industry.

In all your future installations insist on using safety enclosed switches for your entrance or service wires, and wherever possible replace the old fashioned open knife switches with the enclosed type—they may be a little more expensive in the first place, but they are the cheapest in the end.

Enclosed-Fuse Cut-Outs—Plug and Cartridge Type. The bases of all enclosed fuse cut-outs should be made of non-combustible, non-absorptive, insulating material (see page 160). Blocks with an area of over twenty-five square inches must have at least four supporting screws. oles for supporting screws should be so located or countersunk that there will be at least one-half the screw-head or washer and the nearest live metal of an inch space, measured over the surface, between part, and in all cases where between parts of opposite polarity should be countersunk.

Except for sealable service and meter cut-outs, terminals should be either the Edison plug, spring clip or knife blade type, to take the corresponding standard enclosed fuses.

All enclosed fuse cut-outs should be classified as regards both current and voltage as given in the table on pages 163 to 164, and should be so designed that the bases of one class cannot be used with fuses of another class rated for a higher current or voltage.

STANDARD PLUG OR CARTRIDGE CUT-OUTS

Not over 250 Volts	Not over 600 Volts
0- 30 amperes	0- 30 amperes
31- 60 "	31- 60 "
61-100 "	61-100 "
101-200 "	101-200 "
201-400 "	201-400 "
401-600 "	

Sealable Service and Meter Cut-Outs

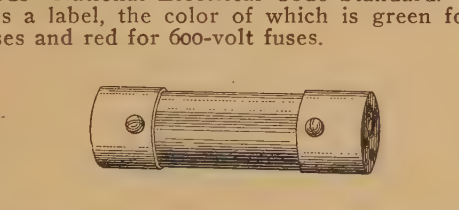
Not over 250 Volts	Not over 600 Volts
0- 30 amperes	0- 30 amperes
31- 60 "	31- 60 "
61-100 "	61-100 "
101-200 "	101-200 "

Enclosed Fuses (Plug Type)

Plugs, commonly known as Edison Fuse Plugs, should not be used to protect circuits of over 30 amperes at 125 volts. This, of course, includes any circuit of a three wire 125-250 volt system with grounded neutral. The large size Edison Plug is designed for circuits between 31 and 60 amperes at 250 volts.

Enclosed Fuses (Cartridge Type)

They should be marked where it will be plainly visible, with the name, trade-mark of the maker, the voltage and current for which the fuse is designed, and the words "National Electrical Code Standard." Each fuse has a label, the color of which is green for 250-volt fuses and red for 600-volt fuses.



Cartridge Fuses—Ferrule and Knife Blade Contacts.

No N. E. C. standard enclosed fuses should ever be refilled by the user but should be returned to their makers, who will refill them at a nominal cost, and in strict accordance with their ratings, thus making them practically new fuses.

When the use of "Renewable" fuses is contemplated, permission for their use should be secured, in writing, from the underwriters' inspection bureau, or local board, having jurisdiction in the locality in which such fuses are intended to be used, unless they are officially approved by the Underwriters' Laboratories.

There are now several types of officially approved Renewable fuses on the market (see pages 165-173).

For dimensions of National Electrical Code Standard fuses and complete specifications see pages 163 to 164.

All Knife Switches should be so wired that blades will be "dead" when switch is open.

Up to 250 volts and thirty amperes, **approved indicating snap switches** are suggested in preference to knife switches on lighting circuits.

Single pole switches should never be used as service switches, nor for the control of outdoor signs or circuits located in damp places, nor placed in the neutral wire of a three wire system, except in the two wire branch, or tap circuit supplying not more than 660 watts.

Three-way switches are considered as single pole switches.

Where flush switches or receptacles are used, whether with conduit systems or not, they should be enclosed in an **approved** box constructed of iron or steel, in addition to the porcelain enclosure of the switch or receptacle.

At floor outlets, attachments plugs and receptacles should be enclosed in **approved** floor outlet boxes especially designed for this purpose.

Where possible, at all switch outlets, unless outlet boxes which will give proper support for switches are used, a seven-eights inch block should be fastened between studs or floor timbers flush with back of lathing to holding tubing and to support switches. When this cannot be done, wooden base-blocks, not less than three-fourths inch in thickness, securely screwed to lathing, should be provided.

Sub-bases of non-combustible, non-absorptive insulating material, which will separate the wires at least one-half inch from the surface wired over, should be installed under all snap switches used in exposed knob and cleat work. Sub-bases should also be used in wooden raceway work, but they may be made of hardwood or they may be omitted if the switch is especially designed and approved for mounting directly on the raceway.

Knife Switches should be mounted on non-combustible, non-absorptive, insulating bases such as slate, marble or porcelain.

Hinges of knife switches should not be used to carry current unless they are equipped with spring washers, held by lock-nuts or pins, or their equivalent, so arranged that a firm and secure connection will be maintained at all positions of the switch blades.

Spring washers should be of sufficient strength to take up any wear in the hinge and maintain a good contact at all times.

All switches should have ample metal for stiffness and to prevent rise in temperature of any part of over 50 degrees Fahrenheit at full load, the contacts being arranged so that a thoroughly good bearing at every point is obtained with contact surfaces advised for pure copper blades of about one square inch for every seventy-five amperes.

They should be plainly marked where it can be read when the switch is installed, with the name of the maker and the current and the voltage for which the switch is designed.

It is not necessary in this section to give all the dimensions and spacings required on knife switches. All the wireman needs to know is that it is of approved type with the maker's name and the current and voltage plainly marked on the switch. For complete specifications (see pages 156 to 159).

Low-Potential Systems

General Installation Suggestions

Any circuit attached to any transforming device, machine, or combination of machines, which develops a difference of potential between any two wires or between any wire and the ground of not over 550 volts, is considered as a low-potential circuit. The primary circuit should not exceed a potential of 3,500 volts, unless the primary wires are installed in accordance with the suggestions given on page 260 for lines of over 5,000 volts, or are underground. For 550-volt motor equipments a margin of ten per cent. above the 550-volt limit will be allowed at the generator or transformer.

All wires, on low-potential systems, should, when entering cabinets, cut-out boxes or junction boxes, except where they are in conduit, armored cable or metal raceway, be protected by non-combustible, non-absorptive, insulating bushings, which fit tightly the holes in the box or cabinet and are well secured in place. The wires should completely fill the holes in the bushings, so as to keep out dust, tape being used to build up the wires if necessary. For concealed

knob and tube work, or for open work in dry places, approved flexible tubing (see page 156), will be accepted in lieu of bushings, providing it extends from the last porcelain support into a wooden cabinet, or is secured to a metal cabinet, cut-out box, junction or switchbox by an approved fitting.

No wiring should be laid in plaster, cement or similar finish, and should never be fastened with staples nor should it be fished for any great distance, and only in places where the inspector can satisfy himself that the rules have been complied with.

Twin wires should never be used, except in conduits, or where flexible conductors are permitted.

All wires exposed to mechanical injury should be suitably protected. When crossing floor timbers in cellars, or in rooms where they might be exposed to injury, wires should be installed in approved conduit, (see page 151), or armored cable (see page 125), or be attached by their insulating supports to the under side of a wooden strip, not less than one-half inch in thickness and not less than three inches in width. Instead of the running boards, guard strips on each side and close to the wires will be accepted. These strips should be not less than seven-eighths inch in thickness and at least as high as the insulators.

Protection on side walls should extend not less than seven feet from the floor and should consist of substantial boxing, retaining an air space of at least one inch around the conductors, closed at the top (the wires passing through bushed holes) or of approved metal conduit or pipe of equivalent strength.

When metal conduit or pipe is used, the insulation of each wire should be reinforced by approved flexible tubing extending from the insulator next below the pipe to the one next above it, unless pipe and wire conform to requirements for conduit (see page 117). The two or more wires of a circuit each with its flexible tubing (when required), if carrying alternating current must be placed within the same iron or steel pipe or raceway to avoid trouble from induction.

In damp places the wooden boxing may be preferable because of the precautions which would be necessary to secure proper insulation if the pipe were used. With this exception, however, iron piping is considered preferable to the wooden boxing, and its use is strongly urged. It is especially suitable for the protection of wires near belts, pulleys, etc.

When wires are run in unfinished attics, or roof spaces they will be considered as concealed, and when run in close proximity to water tanks or pipes, will be considered as exposed to moisture.

In unfinished attics, or roof spaces, wires are considered as exposed to mechanical injury, and should not be run on knobs on upper edge of joists.

For open work in dry places all wires should be rigidly supported on non-combustible, non-absorptive insulators, which will separate the wires from each other and from the surface wired over in accordance with the following table:

Voltage	Distance from Surface	Distance between Wires
0 to 300	½-inch	2½-inch
301 to 550	1-inch	4-inch

Rigid supporting requires under ordinary conditions, where wiring along flat surfaces, supports at least every four and one-half feet. If the wires are liable to be disturbed, the distance between supports should be shortened. In buildings of mill construction, mains of not less than No. 8 B. & S. gage, where not liable to be disturbed, may be separated about six inches, and run from timber to timber, not breaking around, and may be supported at each timber only.

Such wiring should not be "dead-ended" at a rosette, socket or receptacle unless the last support is within twelve inches of the same.

In damp places, or buildings specially subject to moisture or to acid or other fumes liable to injure the wires rubber insulation should be used to protect them against water; and as protection against corrosive vapors, either weatherproof or rubber insulation should be used. They should be rigidly supported on non-combustible, non-absorptive insulators, which separate the wire at least one inch from the surface wired over, and should be kept apart at least two and one-half inches for voltages up to 300, and four inches for higher voltages.

The same rigid supporting should be given such wiring as described on the preceding page.

New York and Chicago do not permit wooden moulding or so-called knob-and-tube work. Chicago permits open work, on knobs or cleats, only under special permission where other approved methods of wiring are impracticable.

Snap Switches

All flush, push-button, door, fixture and other snap switches used on constant-potential systems should have their currnet-carrying parts mounted on non-combustible, non-absorptive, insulating bases, such as slate or porcelain, and the holes for supporting screws should be countersunk not less than one-eighth of an inch. There should in no case be less than three-sixty-fourths of an inch space between supporting screws and current-carrying parts.

Sub-bases should be so designed as to separate the wires at least one-half inch from the surface wired over and be of a non-combustible, non-absorptive, insulating material, except for use with wooden race-ways, where they may be of hard wood.

All snap switches should have ample metal for stiffness and to prevent rise in temperature of any part of over 50 degrees Fahrenheit at full load.

All such switches should "make" and "break" with a quick snap, and should not stop when motion has once been imparted by the button or handle.

No exposed parts of any style of snap switch should be in electrical connection with the circuit and every such switch should be plainly marked with the name or trade-mark of the maker and the current and voltage for which the switch is designed.

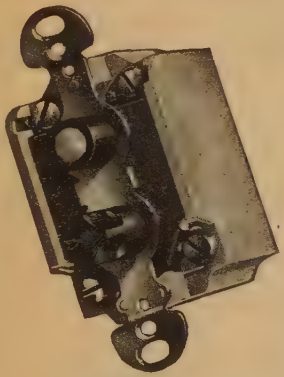
On flush switches these markings are sometimes placed on the sub-plate. On surface switches with covers constructed of porcelain or other moulded insulating material the marking is frequently on the inside of the cover. On all other types they should be placed on the front of the cap, cover or plate.

Switches which indicate whether the current is "on" or "off" are recommended.

Cabinets and Cut-Out Boxes. When cabinets are intended for enclosing feeder and circuit branch panel-boards and similar devices they may be designed for either surface or flush mounting and are usually provided with removable frames or matts, trims, etc., in which the swinging doors are hung. When used to enclose apparatus connected within the cabinet to the wires of more than four circuits they should have a back wiring space or one or more side wiring spaces, side gutters or wiring compartments, unless the wires leave the cabinet directly opposite their terminal connections. When intended for installation out-of-doors they should be of the "weatherproof" pattern.

Cut-out-boxes are intended for enclosing single de-

Set the lower button for whatever lights you wish to use—then operate on and off as any standard single pole switch.



IT IS CALLED
THE ADJUSTABLE
ELECTROLIER
SWITCH

No working through useless circuits. No temporary darkness in obtaining the desired combination of lights.

Made for 2-circuits or 3-circuits, and is the exact equivalent of 2 or 3 single pole switches.

Send for catalog showing complete listings today

The ARROW ELECTRIC CO.

HARTFORD

NEW YORK - CHICAGO - BOSTON
PITTSBURGH - SYRACUSE - SAN FRANCISCO

A TRADE MARK and AN IDEA

In the manufacture of all "DIAMOND H" products, one idea has always predominated. That idea can be expressed fundamentally in three words:—Thoroughness, Quality, Service—Thoroughness is a fundamental of "DIAMOND H" policy, because thoroughness in design, materials and construction can alone produce quality. Quality is a "DIAMOND H" fundamental, because nothing but quality can guarantee service. Service is the "DIAMOND H" ideal, because nothing but service-giving capacity can create a permanent and growing business. In the "DIAMOND H" Trade Mark, this Company has aimed to symbolize the utmost of value to the buyers. How well we have succeeded is best testified to by the fact that a product bearing a

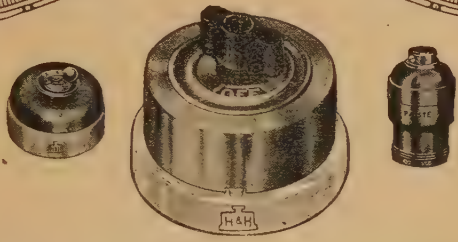
is recognized at once, and has been for over twenty years, as the best in its field.

"DIAMOND H" Switches, Receptacles, Remote Control Switches and Hotel Door Switches.

The Hart Manufacturing Company

HARTFORD, CONN.

H&H



"H & H" Switches

FLUSH SWITCHES 500 VOLT SWITCHES
SNAP SWITCHES
ELECTROLIER SWITCHES
HEATER SWITCHES

"PAISTE" Wiring Material

SOCKETS CUT-OUTS
RECEPTACLES ATTACHMENT PLUGS
ROSETTES PIPE-TAPLETS
MOLDING TAPLETS

THE HART & HEGEMAN MFG. CO.
HARTFORD, CONN., U.S.A.

PAISTE

vices or combinations of devices connected within the cut-out box to the wires of not more than four circuits and usually are designed for surface mounting having swinging doors or covers secured directly to the wall of the box. When intended for installation out-of-doors they also should be of the "weatherproof" pattern.

The construction of all cabinets and cut-out boxes should be such as to insure ample strength and rigidity.

The spacing within cabinets and cut-out boxes should be sufficient to provide ample room for the distribution of wires and cables placed in them, and for a separation between metal parts of cabinets or cut-out boxes and current-carrying parts of devices and apparatus mounted within them (see page 174).

Cabinets and cut-out boxes should be deep enough to allow the doors to be closed when 30-ampere branch circuit panelboard switches having spool or composition handles or switches of combination cut-outs are in any position, and when other single throw switches are thrown open as far as their construction and installation will permit. For full specifications see page 174.

Outlet, Junction and Flush Switch Boxes should be of pressed steel and should be well galvanized, enameled or otherwise properly coated, inside and out, to prevent oxidation.

All such boxes should be plainly marked, where it may readily be seen when installed, with the name or trade-mark of the manufacturer, and should be arranged to secure in position the conduit or flexible tubing protecting the wire.

Switch and outlet boxes should be so arranged that they can be securely fastened in place independently of the support afforded by the conduit piping, except that when entirely exposed **approved** boxes, which are threaded so as to be firmly supported by screwing on to the conduit, may be used.

Switch and receptacle boxes should completely enclose the switch or receptacle on sides and back, and should provide a thoroughly substantial support for it. Boxes for floor outlets should be designed to completely enclose the receptacle and attachment plugs, if any, to protect them from mechanical injury and to exclude moisture.

Covers for outlet boxes if made of metal should be equal in thickness to that specified for the walls of the

box. Covers may also be made of porcelain or other approved material, but should be of such form and thickness as to afford suitable protection and strength. For complete specifications see page 151.

Panel Boards. In the relative arrangement of fuses and switches, the fuses should be placed between the switches and the circuits, so arranging the connections that the switch blades and fuses will be dead when the switches are open. For complete specifications see page 174.

When there are exposed live metal parts on the back of board, a space of at least one-half inch should be provided between such live metal parts and the cabinet in which the board is mounted. All panelboards should be marked where the marking can be plainly seen when installed, with the name or trademark of the manufacturer and the maximum capacity in amperes and the voltage for which the board is designed.

For a really permanent and high class installation of a distributing centre, the following specifications are recommended:

Panel boards should be made as per the Underwriters' Laboratory Label Service Specifications for Panel Board and have label attached (see page 174).

The panelboards should be natural black slate or marine finished marble 7/8-inch thick and equipped on face of panel with such switches, fuse connections, bus bars and other apparatus as follows:—All exposed metal parts should be copper, and wherever not used for contact should be lacquered. All fuse connections for mains and sub-feeders should be for National Electrical Code Standard cartridge fuses, and all fuse connections for circuit branches should be for Edison plug fuses. Each panelboard should be equipped with main switch and main fuse connection. Main fuse connection and main switch and bus bar should be of an ampere capacity equal to the number of circuit branches multiplied by six amperes, **plus** the full ampere capacity of any sub-feeder connections. Each panelboard should be equipped with D. P. circuit branches for the number of circuits shown on wiring plans, and two branches in addition for extra circuits. Each circuit branch should be equipped with D. P. Edison Plug fuse connections and a D. P. 20 ampere push button switch with card holder, and all bus bar and circuit branch switches except operating buttons, to be covered by a

3/32-inch micanite or insulated steel plate so that no live metal parts will be exposed when inner door is open.

Cabinets should be made as per the Underwriters' Laboratory Label Service Specifications for Cabinets and have label attached (see page 174).

Boxes. Cabinet boxes should be made of all steel, of the gutter type and arranged for mounting flush into walls or partitions. The boxes should be formed from one piece of sheet steel, having flanged corners securely fastened with not less than two rivets and with ¾-inch flange turned in at front edges, and when panel is not over 24 inches wide should have gutters as follows:

For panels not over 40 inches high, not less than 3-inch gutter.

For panels over 40 inches high, not less than 4-inch gutters.

Barriers. Cabinets are to be equipped with gutter barriers made in four section of half-inch black slate, of the proper width to allow necessary space between panelboard and front.

Fronts. Front should be made from one piece of sheet steel, of not less than No. 12 U. S. metal gage for boxes of No. 14 gage and not less than No. 10 for larger boxes. There should be two doors in the front, the outer door for exposing the entire panel and the inner door for allowing access to the branch circuit switches only, the outer door to be equipped with suitable lock, the inner door to have catch only.

Raceway Work (Wooden and Metal). All wiring in raceways, either wooden or metal (see page 152) should be done with approved rubber covered wire and should be in continuous lengths from outlet to outlet, or from fitting to fitting, no joints or taps being made in raceways. Where branch taps are necessary in raceway work approved fittings for this purpose should be used.

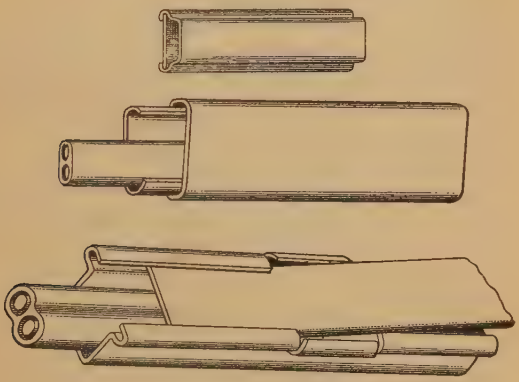
No class of raceway work should ever be done in damp places or in concealed locations or when the difference of potential between any two wires in the same system exceeds 300 volts. When electrical construction is being carried out in metal raceways these raceways may extend through walls and partitions if the raceway and capping are in continuous lengths where passing through the walls and partitions. Not more than four No. 14 B. & S. gage rubber covered wires, and no single circuit of more than 1,320 watts should ever be used in metal raceways.

For alternating current systems if in metal raceways the two or more wires of a circuit should be installed in the same raceway.

In many cases this is being done for direct current systems also, so that they may be changed to alternating systems at any time, induction troubles preventing such a change if the wires are in separate metal raceways.

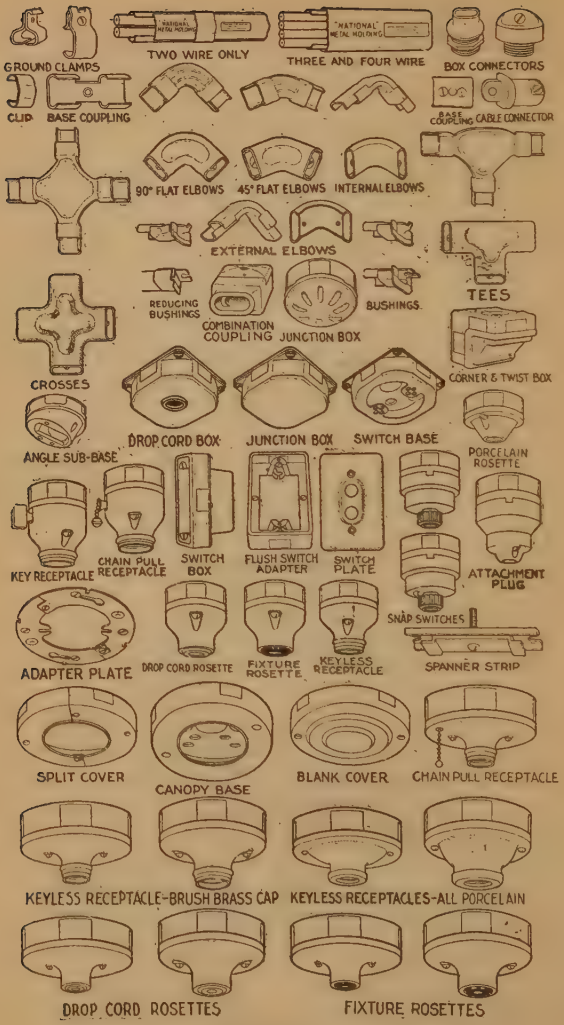
Wooden Raceways. They should have, both outside and inside, at least two coats of waterproof material, or be impregnated with a moisture repellent, should be made of hardwood in two pieces, a backing and a capping, and should afford suitable protection from abrasion. They should be so constructed as to thoroughly encase the wire, be provided with a tongue not less than one-half inch in thickness between the conductors, and have exterior walls which under grooves should not be less than three-eighths inch in thickness, and on the sides not less than one-fourth inch in thickness. New York and Chicago do not permit the use of wooden raceways.

Metal Raceways. Each length of metal raceway should have its maker's name or trade-mark stamped in the metal. (For Installation, see page 82.)



Approved Metal Raceways.

All metal raceways should be constructed of iron or steel at least .050-inch in thickness, if of one piece. If



Metal Raceway Fittings.

they have a backing and capping, the backing should be .050 and the capping not less than .040 inch in thickness, and so constructed that when in place the raceway will be entirely closed. It should be thoroughly galvanized or coated with an **approved** rust preventive both inside and out to prevent oxidation.

Elbows, couplings and all other similar fittings should be constructed of at least the same thickness and quality of metal as the raceway itself, and so designed that they will both electrically and mechanically secure the different sections together and maintain the continuity of the raceway. The interior surfaces should be free from burrs or sharp corners which might cause abrasion of the wire coverings, and at all outlets be so arranged that the conductors cannot come in contact with the edges of the metal, either of capping or backing.

Metal raceways may be used for exposed work only and should be permanently and effectively grounded. For specifications see page 101).

Conduit Work. All wires for this class of work should have an **approved** rubber insulating covering, and within the conduit tubing should be without splices or taps. Such wires should be double braided for twin, twisted pair or multiple conductor cables and for all single conductors of No. 6 B. & S. gage and larger.

Slow burning insulation (see page 125) may, however, be used in permanently dry locations where excessive temperatures are present. No wires should ever be drawn in conduits until all mechanical work on the building has been, as far as possible, completed.

Conductors in vertical conduit risers should be supported within the conduit system in accordance with the following table:

No. 14 to 0 inclusive every 100 feet.

No. 00 to 0000 inclusive every 80 feet.

Above 0000 to 350,000 C. M. inclusive every 60 feet.

Above 350,000 C. M. to 500,000 C. M. inclusive every 50 feet.

Above 500,000 C. M. to 750,000 C. M. inclusive every 40 feet.

Above 750,000 C. M. every 35 feet.

The following methods of supporting cables are recommended:

Approved clamping devices constructed of or employing insulating wedges inserted in the ends of conduits.

Junction boxes (see page 50) may be inserted in the

conduit system at the required intervals, in which insulating supports of approved type should be installed and secured in a satisfactory manner so as to withstand the weight of the conductors attached thereto, the boxes to be provided with proper covers.

Cables may be supported in approved junction boxes on two or more insulating supports so placed that the conductors will be deflected at an angle of not less than 90 degrees, and carried a distance of not less than twice the diameter of the cable from its vertical position. Cables so suspended may be additionally secured to these insulations by tie wires.

For alternating systems the two or more wires of a circuit should be drawn in the same metal conduit. It is advisable, whenever possible, to do the same thing when wiring metal conduit for direct current, as suggested for metal raceways, so that at any time a change might be made from direct to alternating current the necessity of rewirng the conduits would be avoided.

A single conduit should not contain more than four two-wire, or three three-wire circuits of the same system, and should never contain circuits of different systems. **All conduits should be grounded.**

Concealed "Knob and Tube" Work. All wiring of this class should be done with approved rubber covered wire and should be rigidly supported on non-combustible, non-absorptive insulators which separate the wire at least one inch from the surface wired over. When possible, this class of wiring should be run singly on separate timbers, or studding, and kept at least five inches apart.

Such wiring should be separated from contact with the walls, floor timbers and partitions through which they may pass by non-combustible, non-absorptive, insulating tubes, such as glass or porcelain. Wires passing through cross timbers in plastered partitions should be protected by an additional tube extending at least four inches above the timber.

Rigid supporting requires, under ordinary conditions, where wiring along flat surfaces, supports at least every four and one-half feet. If the wires are liable to be disturbed the distance between supports should be shortened.

At distributing centers, outlets or switches, where space is limited and the five-inch separation cannot be maintained, each wire should be separately encased

in a continuous length of **approved** flexible tubing. (See page 156).

When it is impracticable, in this class of work, to place the whole of a circuit on non-combustible supports of glass or porcelain, that portion of the circuit which cannot be so supported should be installed with **approved** metal conduit, or **approved** armored cable (see page 125) except that if the difference of potential between the wires is not over 300 volts, and if the wires are not exposed to moisture, they may be fished if separately encased in **approved** flexible tubing, extending in continuous lengths from porcelain support to porcelain support, from porcelain support to outlet, or from outlet to outlet.

When using either conduit or armored cable in mixed concealed knob-and-tube work, the suggestions for circuit work or armored cable work should be complied with as the case may be.

All wires, in knob-and-tube work, at all outlets, except where conduit is used, should be protected by **approved** flexible tubing, extending in continuous lengths from the last porcelain support to at least one inch beyond the outlet. In the case of combination gas and electric outlets the tubes on the wires should extend at least flush with the outlet ends of gas caps, and if box or plate is used, gas pipes should be securely fastened into the outlet box of plate to secure good electrical connection.

When the surface at any outlet is broken, it should be repaired so as to leave no holes or open spaces at such outlet.

In the best practice **approved** outlet boxes or plates are installed at all outlets, and the wires are protected by **approved** flexible tubing, extending in continuous lengths from the last porcelain support into the box.

Porcelain knobs, tubes, cleats and bushings (see page 153) should have the manufacturer's name, initials or trade-mark stamped in the porcelain.

Tubes and bushings should be straight and free from rough projections and with their ends and interiors smooth and rounded.

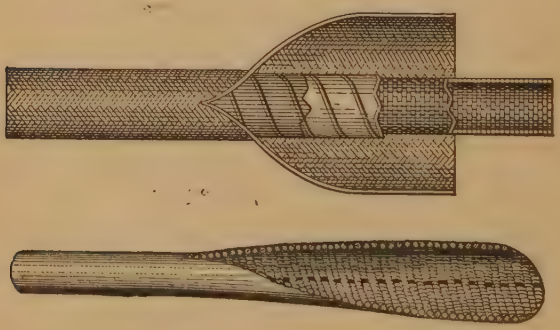
Cleats should hold the wires firmly in place without injury to the covering. All cleats for voltages up to 300 should separate the wires one-half inch from the surface wired over and two and one-half inches from each other.

Split knobs should be constructed in two parts, a base and a cap, arranged to hold the wire firmly in

place without injury to its covering. Solid knobs should be constructed with smooth groove, to contain wire.

Bearing points on the surface wired over should be made by a ring or by ridges on the outside edge of the base, to provide for stability. At least one-fourth inch surface separation should be maintained between the supporting screw or nail and the conductor, and the knob should be so constructed that the supporting screw or nail cannot come in contact with the conductor. For wires larger than No. 4 B. & S. gage, split knobs (or single wire cleats) should be so constructed as to require the use of two supporting screws. Knobs should separate the wire at least one inch from the surface wired over.

New York and Chicago do not permit knob-and-tube work.



Samples of Approved Flexible (Non-Metallic) Tubing.

Flexible Tubing. This should have a sufficiently smooth interior surface to allow the ready introduction of the wire and be constructed of or treated with materials which will serve as moisture repellents.

The tube should be so designed that it will withstand all the abrasion likely to be met with in practice and the linings, if any, should not be removable in lengths of over three feet.

The one-fourth inch tube should be so flexible that it will not crack or break when bent in a circle with six-inch radius at 50 degrees Fahrenheit, and the cov-

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The Standard for Sixteen Years.

"Alphaduct" has always combined perfect flexibility of conduit with great strength, durability and solidity of wall.

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Easy-Bending Spellerized Steel Tube, Protected by a Heavy Coating of Pure Zinc. Clean Threads, Smooth Enameled Interior.

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Fibre Spiral Interior, covered by Insulating Tape and a Heavy Woven Cotton Jacket.

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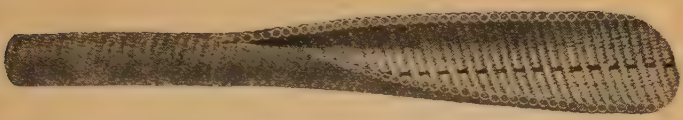

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FLEXIBLE NON-METALLIC CONDUIT

The single interwoven wall of DURADUCT gives great strength and durability to the tubing, at the same time making it extremely flexible.

The "roller-bearing wireway" makes fishing easy and saves time, labor and money in installations.

You will know DURADUCT by the black dotted line on the inner surface.

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ering should be thoroughly saturated with a dense moisture-proof compound. Other sizes must be as well made and none should convey fire on the application of a flame to the exterior of the tube when held in a vertical position.

All flexible tubing should be sufficiently tough and tenacious to withstand severe tension without injury.

It should have a distinctive marking the entire length of the tube, so that it may be readily identified.

Armored Cables. When wiring is done with armored cable, the cables should be continuous from outlet to outlet or to junction boxes or cabinets, and the armor of the cable should properly enter and be secured, **and be permanently and effectively grounded** (see Grounding on page 101).

In case of service connections and main runs, this involves running such armored cable continuously into a main cut-out cabinet or gutter surrounding the panelboard, as the case may be.

Armored cables should be equipped at every outlet with an **approved** outlet box, as recommended in conduit work.

For concealed work in walls and ceilings composed of plaster on wooden joist or stud construction, outlet boxes and also cut-out cabinets should be so installed that the front edge will not be more than one-fourth inch back of the finish surface of the plaster, and if this surface is broken or incomplete it should be repaired so that it will not show any gaps or open spaces around the edges of the outlet box or of the cut-out cabinet. On wooden walls or ceilings, outlet boxes and cut-out cabinets should be so installed that the front edge will either be flush with the finished surface or project therefrom. This need not apply to concealed work in walls or ceilings composed of concrete, tile or other non-combustible material.

In buildings already constructed where the conditions are such that outlet boxes can not be installed, these appliances may be omitted provided approved fittings having separately bushed holes for each conductor are used for terminating armored cables and the wires pass from the conduit or cable without splice, joint or tap. If the armored cable system consists of several separate sections, the sections should be bonded to each other, and the system grounded, or each section may be separately grounded (see page 101).

The armor of cables and gas pipes should be securely fastened in outlet boxes, junction boxes and cabinets,

so as to secure good electrical connection.

If armor of cables and metal of couplings, outlet boxes, junction boxes, cabinets or fittings have protective coating of non-conducting material, such as enamel, such coating should be thoroughly removed from the threads of both couplings and armor of cables, and from surfaces of the boxes, cabinets and fittings where the armor or cables or ground clamp is secured in order to obtain the requisite good connection. Grounded pipes should be cleaned of rust, scale, etc., at place of attachment of ground clamp.

Connections to grounded pipes and to armor of cables should be exposed to view or accessible and should be made by means of **approved** ground clamps.

Ground wires should be of copper, at least No. 10 B. & S. gage (where largest wire contained in cable is not greater than No. 0 B. & S. gage), and need not be greater than No. 4 B. & S. gage (where the largest wire contained in cable is greater than No. 0 B. & S. gage).

When armored cables are installed in so-called fireproof buildings in course of construction or afterwards if exposed to moisture, or where it is exposed to the weather, or in damp places, such as breweries, stables, etc., the cable should have a lead covering placed between the outer braid of the conductors and the steel armor.

This lead covering is not necessary when the cable is run against brick walls or laid in ordinary plaster walls unless same are continuously damp.

When entering junction boxes, and at all other outlets, etc., armored cable should be provided with **approved** terminal fittings which will protect the insulation of the conductors from abrasion, unless such junction or outlet boxes are specially designed and approved for use with the cable.

Junction boxes should always be installed in such a manner as to be accessible.

For alternating current systems armored cable should have the two or more conductors of the circuit enclosed in one metal armor.

All bends should be so made that the armor of the cable will not be injured. The radius of the curve of the inner edge of any bend should not be less than one and a half inches.

The conductors in armored cable should be rubber covered.

Metal Conduits

Conduit smaller than one-half inch electrical trade size should never be used.

A conduit installation should be continuous from outlet to outlet or to junction boxes or cabinets, and the conduit should properly enter, and be secured to all fittings and the entire system mechanically secured in position and free from burs.

Samples of Rigid Interior Metal Conduit with Coupling.

In case of service connections and main runs, this involves running each conduit continuously into a main cut-out cabinet or gutter surrounding the panelboard, as the case may be.

Before wires are drawn into conduit, all construction work in building should have been completed, as far as possible.

Conduit systems should be equipped at every outlet with an **approved** outlet box; where a box cannot be used an outlet plate should be used. At exposed ends of conduit (but not at fixture outlets) where wires pass from the conduit system without splice, joint or tap, an **approved** fitting having separately bushed holes for each conductor should be used.

For concealed work in walls and ceiling composed of plaster on wooden joist or stud construction, outlet boxes and also cut-out cabinets should be so installed that the front edge will not be more than one-fourth inch back of the finished surface of the plaster, and if this surface is broken or incomplete it should be repaired so that it will not show any gaps or open spaces around the edges of the outlet box or the cut-out cabinet. On wooden walls or ceilings, outlet boxes

RIGID STEEL CONDUIT

NO BETTER
ENAMELED CONDUIT
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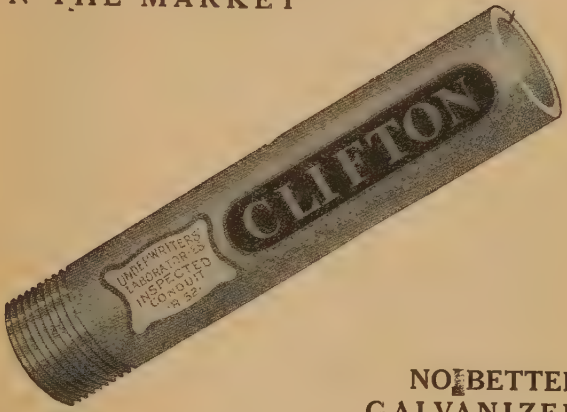

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GALVANIZED
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"BLACK" ENAMELED AND
"WHITE" GALVANIZED

Friction Tape — Splicing Compounds
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CONDUIT WORK

MODERN construction makes essential the use of an armor of metal protection to electric wires; mechanical injury during construction or after completion of the work causes such annoyance, expense and damage, that the first cost of a conduit system over knob and tube work, exposed wiring, molding or non-metallic tubing construction is now considered of no consequence when safety by metallic conduit protection is secured.

FIRST IN PROTECTIVE QUALITIES IS

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"Sterling" Flexible Steel Conduit
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"Sterling" Steel Armored Conductor
(All Patented)

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SUCCESSOR TO

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Galvanized Pipe

"NAVALITE"
Enameled Pipe

For Electric Wire Conduits

Made from the ore to finished product in our plants.

Inspected and Labeled under direction of the
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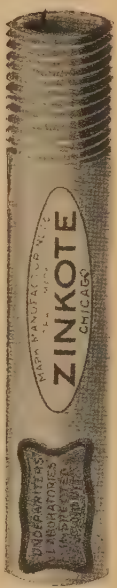

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Metal Moldings, Fittings and Devices
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RUBBER COVERED WIRE

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Sprague
Wiring Materials

The Sprague Works are pioneers in the Conduit Industry.

For years the better class of Engineers and Contractors have chosen Sprague Conduit, Boxes, and Fittings, in preference to all others because they represent the safest and best and have been

The Standard for Years

When you specify or use any of the material listed below, you are employing the most enduring the market affords.

BX (Spragues well-known steel armored conductor)
SINGLE STRIP CONDUCTOR (Modified BX)
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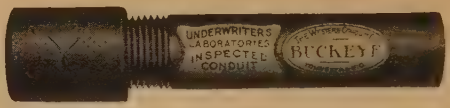

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BUCKEYE Conduit is made from the best steel pipe we can produce for that especial purpose. It is finished in the best manner and with the utmost care in both enamel and electro-galvanizing.

REALFLEX is now recognized as the most flexible, durable and handsome of all armored conductors. It is made in a number of different sizes and for a number of special uses.

You want the best. Try them.

Catalogue on application.

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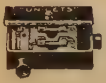
"Unilets"

Reg. U. S. Pat. Off.

and Other Conduit Fittings

"A Fitting for Every Requirement"

EACH and every "Unilet," also other Conduit Fittings have been designed for the difficult problems met with in installations. No matter what may be your requirements, you will find the needed fitting listed in the catalog of Appleton Products.



The Fittings illustrated in this space are but a small part of those to be found listed in our large catalog and supplementary bulletin. Copy of this catalog and bulletin will be of assistance to you in many instances.

"Unilets" and the majority of Appleton Products are made from steel, which insures greater wiring space, and being lighter in weight are handled much easier than numerous other makes of fittings. "Unilets" can be furnished either with Black Enameled or Hot Galvanized finish. We suggest the latter where there is considerable moisture, etc. All other Conduit Fittings are furnished either with Black Enameled or Electro-Galvanized finish.

Catalog and bulletin issued in two sizes. 8 x 10½ for general use and handy pocket size, 4 x 5¼. We will be glad to send these upon request. Write today.

Appleton Products include

"Unilets," Outlet Boxes and Covers, Laundry Fittings, Locknuts and Bushings, Meter Terminal Fittings, Entrance Fittings, Fuse Wire and Links, "Pagrip" Metal Molding and Fittings, Conduit Clamps and Hangers, also Switch Boxes.

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TYPE Q E D
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TYPE Q E D
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For service entrance work furnished with two-piece, three-hole insulator. Seal furnished to close unused hole when used with but two wires. Brass screws. Galvanized finish. Insulators for sizes 1" and under, made of approved molded insulation; above 1", of porcelain. Can be applied after service is connected up by cutting out reduced section of frame with hack-saw.

LIST PRICES.

No.	Size.	Unit Pkg.	Each.
6012	½"	10	$ .45
6034	¾"	10	.50
6001	1 "	5	.90
6114	1¼"	2	1.50
6112	1½"	2	2.00
6002	2 "	2	3.00
6212	2½"	1	4.50
6003	3 "	1	7.00

Terminal, Form "A"

For motor loop, meter loop, and other inside work. A cast terminal. Galvanized finish. Same insulators as service cap.

LIST PRICES.

No.	Size.	Unit Pkg.	Each.
10012	½"	10	$ .32
10034	¾"	10	.35
10001	1 "	5	.63
10114	1¼"	2	.92
10112	1½"	2	1.20
10002	2 "	2	2.10
10212	2½"	1	4.00
10003	3 "	1	6.50

Box Connectors

Made in three styles to meet any wiring requirement. A connector which does away with the awkward, bothersome nut; fastening with an "easy-to-get-at" screw. Fits standard outlet boxes with ⅞" knockouts. Holds flexible or armored cable with equal grip. Will hold cable 11/16" dia. and smaller.

No.	Style.	Unit Pkg.	Each.
731	Straight	100	$.07½
734	45	25	.11
738	90	25	.12

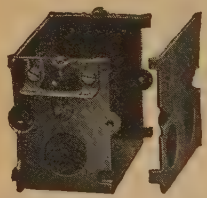
Also Manufacturers of Approved GROUND CLAMPS UNIVERSAL ENTRANCE FITTINGS, MOULDING BOXES, BOX CLAMPS

THE GILLETTE-VIBBER CO.
TRADE MARK
NEW LONDON, CONNECTICUT.

BETTER BG GOODS

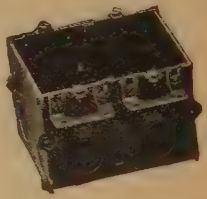
ANNOUNCEMENT OF

B-G SECTIONAL SWITCH BOXES



B-G No. 502, Single Gang with side detached

IN THE DEVELOPMENT OF B-G SECTIONAL SWITCH BOXES, WE HAVE THE "LAST WORD" OF ITS KIND TO OFFER TO THE ELECTRICAL TRADE.



B-G No. 502, Two Gang Assembly

They are the Embodiment of ECONOMY

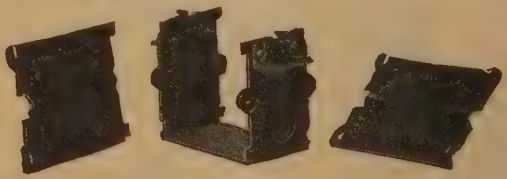
The B-G Patent Locking Devices eliminate the use of screws entirely in assembling two or more gangs. This means a big saving in labor of 5 to 10 minutes over other boxes as well as saving material.

SIMPLICITY

As all sides are interchangeable, it is impossible to assemble the box incorrectly. The sides lock with the spacer by a quick snap and is tighter than screw assembled boxes.

A MORE PERFECT JOB

With the B-G locking device, a job is more perfectly installed and more fully meets the requirements of the trade for a sectional switch box.



B-G PRODUCTS Comprise Stamped Steel COVERS, Patented Stamped Steel OUTLET, JUNCTION and SWITCH BOXES and FIXTURE STUDS.

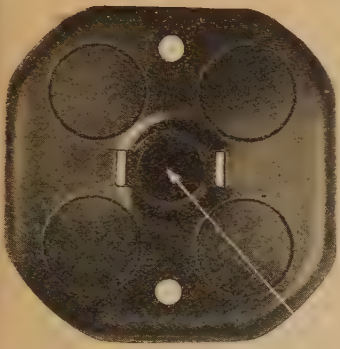
WRITE FOR DESCRIPTIVE CATALOGUE

THE TOLEDO METAL PRODUCTS COMPANY

GENERAL OFFICES
956-959 SPITZER BLDG.

TOLEDO, OHIO

BETTER BG GOODS



B-G

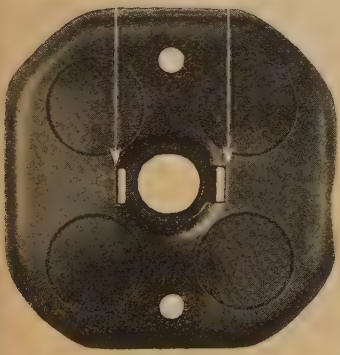
Products Comprise

Stamped Steel Covers,
Patented Stamped Steel Outlet,
Junction and Switch Boxes and Fixture Studs

Their Superior Advantages are—

SAFETY
ECONOMY
ACCESSIBILITY
SIMPLICITY

and More Perfect Installation



WRITE FOR CATALOGUE

THE TOLEDO METAL PRODUCTS COMPANY

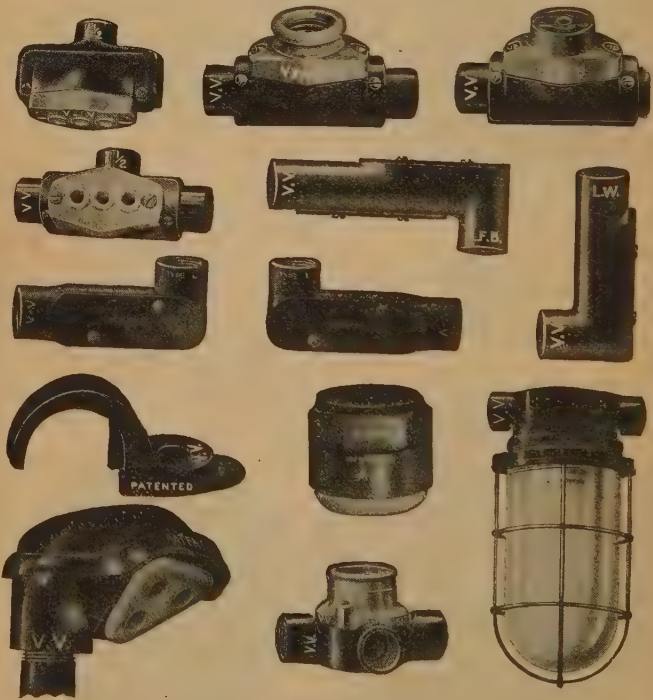
GENERAL OFFICES
956-959 SPITZER BLDG.

TOLEDO,
OHIO

V. V. FITTINGS

A Complete Line With A Few Parts

Two types in one—a straight pull on the wires—lots of working room—easy wiring and a neat job are some of the many features embodied in these fittings.



V. V. FITTINGS COMPANY

PHILADELPHIA, PA.

NEW YORK
50 Church Street

CHICAGO
308 S. Canal Street

or plates and cut-out cabinets should be so installed that the front edge will either be flush with the finished surface or project therefrom. This is not necessary in concealed work in walls or ceilings composed of concrete, tile or other non-combustible material.

In buildings already constructed where the conditions are such that an outlet box can not be installed, these appliances may be omitted, providing the conduit ends are bushed and secured.

Metal conduits where they enter junction boxes, and at all other outlets, should be provided with **approved** bushings or fastening plates fitted so as to protect wire from abrasion.

In all conduit systems the metal of the conduit should be permanently and effectually grounded to water piping, gas piping or other suitable grounds, provided that when connections are made to gas piping, they are on the street side of the meter. If the conduit system consists of several separate sections, the sections should be bonded to each other, and the system grounded, or each section may be separately grounded. Where short sections of conduit (or pipe of equivalent strength) are used for the protection of exposed wiring on side walls such conduit or pipe need not be grounded.

Conduits and gas pipes should be securely fastened in outlet boxes, junction boxes and cabinets, so as to secure good electrical connections.

If conduit, couplings, outlet boxes, junction boxes, cabinets or fittings, having protective coating of non-conducting material, such as enamel, such coating should be thoroughly removed from threads of both couplings and conduit, and such surfaces of boxes, cabinets and fittings where the conduit of ground clamp is secured in order to obtain the requisite good connection. Grounded pipes should be cleaned of rust, scale, etc., at place of attachment of ground clamp.

Connections to grounded pipes and to conduit should be exposed to view or accessible, and be made by means of **approved** ground clamps.

Ground wires should be of copper, at least No. 10 B. & S. gage (where largest wire contained in conduit is not greater than No. 0 B. & S. gage), and need not be greater than No. 4 B. & S. gage (where largest wire contained in conduit is greater than No. 0 B. & S. gage).

SIZE OF CONDUITS FOR THE INSTALLATION OF WIRES AND CABLES. NUMBER OF CONDUCTORS IN SYSTEM.

	One conductor in a conduit. Size conduit, in.	Two conductors in a conduit. Size conduit, in.	Three conductors in a conduit. Size conduit, in.	Four conductors in a conduit, Size conduit, in.
Size B & S.	Electrical Trade Size	Electrical Trade Size	Electrical Trade Size	Electrical Trade Size
14	½	½	½	¾
12	½	¾	¾	¾
10	½	¾	¾	1
8	½	1	1	1
6	½	1	1¼	1¼
5	¾	1¼	1¼	1¼
4	¾	1¼	1¼	1½
3	¾	1¼	1¼	1½
2	¾	1¼	1½	1½
1	¾	1½	1½	2
0	1	1½	2	2
00	1	2	2	2½
000	1	2	2	2½
0000	1¼	2	2½	2½
CM				
200000	1¼	2	2½	2½
250000	1¼	2½	2½	3
300000	1¼	2½	2½	3
400000	1¼	3	3	3½
500000	1½	3	3	3½
600000	1½	3	3½	
700000	2	3½	3½	
800000	2	3½	4	
900000	2	3½	4	
1000000	2	4	4	
1250000	2½	4½	4½	
1500000	2½	4½	5	
1750000	3	5	5	
2000000	3	5	6	

For sizes not greater than No. 10 B. & S. gage, one more conductor than permitted by the above table may be installed in the specified conduit, provided the conduit is not longer than 30 feet, and has not more than the equivalent of two quarter bends from outlet to outlet. the bends at the outlets not being counted.

3 CONDUCTOR CONVERTIBLE SYSTEM.

Size of Conductors		Size Conduit, in.
2-conductor Size B. & S.	1-conductor Size B. & S.	Electrical Trade Size
two 14	and one 10	¾
12	8	¾
10	6	1
8	4	1
6	2	1¼
5	1	1¼
4	0	1½
3	00	1½
2	000	1½
1	0000	2
0	250000	2
00	350000	2½
000	400000	2½
0000	550000	3
250000	600000	3
300000	800000	3
400000	1000000	3½
500000	1250000	4
600000	1500000	4
700000	1750000	4½
800000	2000000	4½

SINGLE CONDUCTOR COMBINATION.

NOTE—Where special permission has been secured to use more than four two-wire, or three three-wire circuits in a single conduit, the following table to apply:

No. of Wires	Size Conduit, in. Electrical Trade Size
10 No. 14 R.C. solid	1
18 No. 14 R.C. solid	1¼
24 No. 14 R.C. solid	1½
40 No. 14 R.C. solid	2
74 No. 14 R.C. solid	2½
90 No. 14 R.C. solid	3

Junction boxes should always be installed in such a manner as to be accessible.

All elbows or bends in a conduit installation should be so made that the conduit will not be injured. The radius of the curve of the inner edge of any elbow should not be less than three and one-half inches. The conduit should have not more than the equivalent of

four quarter bends from outlet to outlet, the bends at the outlets not being counted.

Elbows, bends and similar fittings must be made of full-weight material, such as is specified for the conduit proper, and must be treated, coated, threaded, etc., in a manner corresponding to the specifications for conduit, so far as they apply.

Threads upon conduits, couplings, elbows and bends should be full and clean cut. Their pitch and form should conform to the Briggs' standard for pipe threads.

If threads are cut after the protective coatings are applied they should be treated to prevent corrosion taking place before the conduit is actually installed.

The number of threads of the threaded portion should be in accordance with the following table:

Electrical Trade Size, Inches.	Number of Threads per Inch.
¼	18
⅜	18
½	14
¾	14
1	11½
1¼	11½
1½	11½
2	11½
2½	8
3	8
3½	8
4	8
4½	8
5	8
6	8

The finished conduit as shipped should be in ten-foot lengths, with each end reamed and threaded. For each length at least one coupling should be furnished.

The finished conduit with coupling should not weigh less than is given in the following table:

Electrical Trade Size, Inches.	Minimum Weight of Ten 10-foot Lengths of Finished Conduit, with Couplings. Pounds.
¼	38.5
⅜	51.5
½	79.0
¾	105
1	153
1¼	201
1½	249
2	334
2½	527
3	690
3½	831
4	982
4½	1150
5	1344
6	1770

Flexible Metallic Conduits should be so flexible that the conduit may be bent in a curve, the inner edge of which has a radius equal to that specified in the following table, without opening up the tube at any point.

Electrical Trade Size Inches	Internal Diameter Inches	Thickness of Strip Inches	Weight in Pounds per 100 ft. Single Strip	Weight in Pounds per 100 ft. Double Strip	Radius of Curvatures Inches
5/16	5/16	.025	17¾	20½	2¼
⅜	⅜	.034	29	33½	2½
½	½	.040	54	62	3½
¾	13/16	.040	68	78½	4½
1	1	.055	108	129½	5
1¼	1¼	.055	132	158	5½
1½	1½	.060	171	205	6
2	2	.060	224	269	8
2½	2½	.060	277	332	10½

If of steel the metal should be thoroughly galvanized or coated with an approved rust preventive.

Metal Raceways. Every installation of metal raceways should be continuous from outlet to outlet, to junction boxes, or approved fittings designed especially for use with metal raceways, and should at all outlets be provided with approved terminal fittings which will protect the insulation of conductors from abrasion, unless such protection is afforded by the construction of the boxes or fittings.

Such raceways where passing through a floor should be carried through an iron pipe extending from the ceiling below to a point five feet above the floor, which will serve as an additional mechanical protection and exclude the presence of moisture often prevalent in such locations.

Where the mechanical strength of the raceway itself is adequate, the protecting piping from the ceiling below need extend only to a point three inches above the flooring.

Where such raceways pass through a partition the iron pipe required for passing through floors may be omitted and the raceway passed directly through, providing the partition is dry and the raceway is in a continuous length with no joint or coupling within the partition.

The backing of all metal raceways should be secured in position by screws or bolts, the heads of which should be flush with the metal.

The metal of raceways should be permanently and effectually grounded to water piping, gas piping, or other suitable grounds, provided that when connections are made to gas piping, they should be on the street side of the meter. If the metal raceway system consists of several separate sections, the sections should be bonded to each other and the system grounded, or each section may be separately grounded (see page 101).

Metal raceways and gas pipes should be securely fastened to outlet boxes, junction boxes and cabinets, so as to secure a good electrical connection. Raceways should be so installed that adjacent lengths of raceway will be mechanically and electrically secured at all points.

If metal raceways, couplings, outlet boxes, junction boxes, cabinets or fittings have protective coating of non-conducting material such as enamel, such coating should be thoroughly removed from the couplings of the metal raceways, and from the surfaces of boxes, cabinets and fittings, where the metal raceway or

ground clamp is secured in order to obtain the requisite good connection.

Connection to grounded pipes and to metal raceways should be made by means of approved ground clamps, and the ground wires should be copper, at least No. 10 B. & S. gage.

As the two or more wires of an alternating current circuit are required to be placed in a single iron conduit, to prevent induction trouble, so must similar circuits be placed in single metal raceways.

FIXTURE WIRING

All lighting fixtures which are not grounded in accordance with the suggestions on grounding given on page 101 should be insulated from their supports by approved insulating joints placed as close as possible to the ceilings or walls (see page 87).

Where insulating joints are used, fixture canopies of metal should be thoroughly and permanently insulated from metal walls or ceilings or from plaster walls or ceilings on metal lathing and from outlet boxes. Canopy insulators (see page 87) should be securely fastened in place so as to separate the canopies thoroughly and permanently from the surface and outlet boxes from which they are designed to be insulated.

Gas pipes should be protected above the insulating joints or blind hickeys by approved insulating tubing, and where outlet tubes are used they should be of sufficient length to extend below the insulating joint and should be so secured that they will not be pushed back when the canopy is put in place.

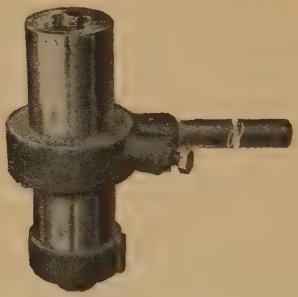
Insulating joints and canopy insulators may be omitted in the following cases:

1. Straight electric fixtures connected to knob-and-tube, wooden raceway or open work, except on metal ceilings or on plaster walls or ceilings containing metal lathing.

2. Straight electric fixtures in which all wires have an approved rubber insulation not less than 3/64th inch in thickness and which are metallically connected in a permanent and effective manner to metal conduit, armored cable or metal raceway systems or to gas piping, provided such gas piping is properly grounded (see Grounding, page 101).

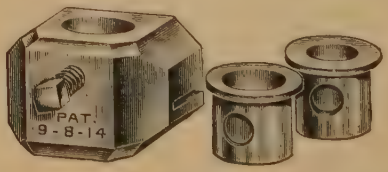
ARMSTRONG

CEILING NIPPLE THREADER FOR ATTACHING FIXTURES



EVERY CONTRACTOR AND WIREMAN SHOULD HAVE ONE IN HIS TOOL BAG. THIS TOOL THREADS PIPES $\frac{1}{4}$, $\frac{3}{8}$, AND $\frac{1}{2}$ INCH. IF USED WITH OUR HACK SAW GAUGE BLOCK, AS SHOWN BELOW, WILL PAY FOR ITSELF IN A SHORT TIME.

ARMSTRONG
HACK SAW GAUGE BLOCK



This tool will gauge the distance of pipe extending thru the ceiling or wall.

It is so constructed that it can be set at any distance by tightening the set screw so as to cut the proper lengths.

The slot in the side is a guide for the hack saw blade —cuts end square and without a burr.

THE ARMSTRONG MFG., CO.

360 KNOWLTON ST. BRIDGEPORT, CONN.
NEW YORK OFFICE—248 CANAL ST.

3. Straight electric fixtures, in which all wires have an approved rubber insulation not less than 3/64th inch in thickness and which are permanently and effectively grounded to a separate ground wire not smaller than No. 14 B. & S. gage.

4. Combination fixtures in which all wires have an approved rubber insulation not less than 3/64th inch in thickness and where gas piping is properly grounded (see par. 2, above). For outdoor use they should be of water-tight construction.

Fixture wires (see page 124) should be not smaller than No. 18 B. & S. gage, and should have an approved rubber insulating covering.

In wiring certain design of show-case fixtures, ceiling bulls-eyes and similar appliances in which the wiring is exposed to temperatures in excess of 120 degrees Fahrenheit from the heat of the lamps, **approved** slow-burning wire should be used. See page 125.

Supply conductors, and especially the splices to fixtures wires, should be kept clear of the grounded part of gas pipes, and, where shells or outlet boxes are used, they should be made sufficiently large.

When fixtures are wired on the outside the conductors should be so secured as not to be cut or abraded by the pressure of the fastenings or motion of the fixtures.

Fixtures thus wired should not be used in show windows or in the immediate vicinity of especially inflammable stuff.

Chain fixtures should be wired with flexible conductors, and such fixtures may be used in show windows if kept free from inflammable material.

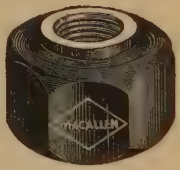
Wires of different systems should never be contained in or attached to the same fixture, and under no circumstances should there be a difference of potential of more than 300 volts between wires contained in or attached to the same fixtures.

Fixture Wires, which may be either solid or stranded conductor, should never be smaller than No. 18 B. & S. gage (no wire smaller than No. 14 B. & S. gage should be used elsewhere than in or on fixtures) and should conform to the specifications given on page 124.

Canopy Insulators should be of **approved** types. They should be securely fastened in place so as to separate the canopies thoroughly and permanently from the surfaces and outlet boxes from which they are designed to be insulated.

Each fixture (after wiring and assembly) should be

MACALLEN
ARMORED
INSULATING JOINTS



This **ARMORED** Joint is the result of over 25 years' experience in the manufacture of Insulating Joints.

Canopy Insulators

Both the above devices regularly inspected and labeled under the supervision of the Underwriters' Laboratories, Inc., under the direction of the National Board of Fire Underwriters.

TRADE MACALLEN MARK.

The Macallen Company
Macallen & Foundry Streets
Boston, Mass.

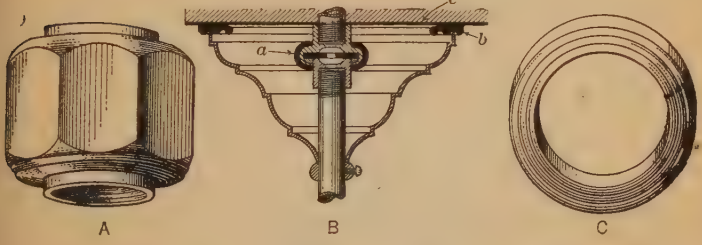
Catalogues and Price Lists Furnished Upon Application.

tested with a magneto which will ring through a resistance of at least 50,000 ohms and show no short circuits between conductors or contacts between conductors and metal parts of fixtures.

Each fixture should be marked with the manufacturer's name or trade-mark.

Insulating Joints. All a wireman needs to know about an insulating joint is that it is officially approved and bears the maker's name or trade-mark. See specifications on page 184.

The same is true of Canopy Insulators.



A, Insulating Joint. B, Canopy and Insulating Joint in Position. C, Canopy Insulator.

Weatherproof Sockets. In rooms where inflammable gases may exist the incandescent lamp and socket should be enclosed in a vapor-tight globe, and supported on a pipe-hanger, wired with **approved** rubber-covered wire soldered directly to the circuit.

In damp or wet places, or where exposed to corrosive vapors, weatherproof sockets especially approved for the location should be used. Unless made up on fixtures they should be hung by separate **stranded** rubber-covered wires not smaller than No. 14 B. & S. gage, which should preferably be twisted together when the pendant is over three feet long.

These wires should be soldered direct to the circuit wires but supported independently of them.

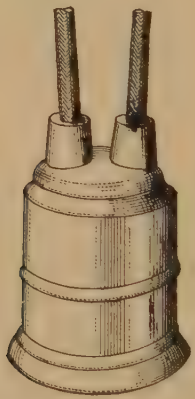
Sockets and receptacles installed over specially inflammable stuff or where exposed to flyings of combustible material, should be of the keyless type, and unless individual switches are provided, should be installed at least seven and one-half feet above the floor, or should be so located or guarded that the

lamps cannot be readily backed out by hand.

When the socket is not attached to a fixture, the inlet if threaded should be not less than three-eighth inch pipe size, and should be provided with an **approved** insulating bushing.

Sockets and Lamp Receptacles. Lamp holding devices are classified according to the diameters of the lamp bases. One-half inch are known as Candelabra, one inch as Medium, and one and a half inch as Mogul Bases and are rated as in the table on page 179.

All sockets and receptacles should be marked with the name or trade-mark of the manufacturer and with the watts and volts which apply to the class. The



Weatherproof Keyless Socket for damp places.

rating marks may be abbreviated as, for example, "250 W., 250 V." See specifications on page 179.

Rosettes for ceiling work, both fused and fuseless, should have all their current-carrying parts mounted on porcelain, and be plainly marked where it may readily be seen after the rosette has been installed, with the name or trade-mark of the manufacturer, and the rating in amperes and volts. Fuseless rosettes are rated three amperes, 250 volts; fused rosettes with link fuses, not over two amperes, 125 volts. See specifications on page 178.

Flexible Cord and Its Uses. Where the difference of potential between the two wires is over 300 volts, flexible cord should not be used, nor should flexible cord be used as a support for clusters. It should be used only for pendants, wiring of fixtures, portable lamps or motors, portable heating apparatus or other portable devices.

For all portable work, including those pendants which are liable to be moved about sufficiently to come in contact with surrounding objects, flexible wires and cables especially designed to withstand this severe service should be used. See page 125.

When necessary to prevent portable lamps from coming in contact with inflammable materials, or to protect them from breakage, they should be surrounded with substantial guards.

Unless provided with **approved** metal armor, flexible cord should not be used in show windows or in show cases. Approved portable card may be used in show windows for the purpose of supplying current to portable lamps and other devices for exhibition purposes, and flexible cord may be used for chain fixtures only.

Flexible cord should be protected by approved insulating bushings where the cord enters a lamp socket.

It should be so connected to all fittings that strain is taken from the joints and binding screws.

When passing through covers of outlet boxes it should be protected by **approved** bushing especially designed for this purpose, or the cover provided with a smooth well rounded surface on which the cord will bear.

Arc Lamps on Constant-Potential Circuits. Where arc lamps may be installed—although they are now rapidly being displaced by Mazda or tungsten lamps (see page 366), a cut-out for each lamp or each series of lamps should be provided.

The branch conductors should have a carrying capacity about 50 per cent. in excess of the normal current required by the lamp.

They should be furnished with only such resistances or regulators as are enclosed in non-combustible material, such resistances being treated as sources of heat. Incandescent lamps, however, should not be used for this purpose.

All such arc lamps should be supplied with globes and protected by spark arresters and wire netting around the globe.

Outside arc lamps should be suspended at least eight feet above sidewalks. Inside arc lamps should be placed out of reach or suitably protected.

Lamps when arranged to be raised or lowered, either for carboning or other purposes, should be connected up with stranded conductors from the last point of support to the lamp, when such conductor is larger than No. 14 B. & S. gage.

Economy and compensator coils for arc lamps should be mounted on non-combustible, non-absorptive, insulating supports, such as glass or porcelain, allowing an air space of at least one inch between frame and support, and should in general be treated as sources of heat.

Mercury Vapor Lamps. Lamps of this kind (see page 374 should have a cut-out for each lamp or series of lamps except when contained in single frame and lighted by a single operation, in which case not more than five lamps should be dependent upon a single cut-out.

They should only be furnished with such resistances or regulators as are enclosed in non-combustible cases, such resistances to be treated as souces of heat. In locations where these resistances or regulators are subject to flyings of lint or combustible materials, all openings through cases must be protected by fine wire gauze.

Gas Filled Incandescent Lamps. Mazda or tungsten gas filled lamps (see page 366) should be so grouped that not more than 660 watts (nor more than 16 sockets or receptacles) will be dependent on one cut-out, except that in cases where wiring equal in size to No. 14 B. & S. gage is carried directly into keyless sockets or receptacles, the location of which is such as to render unlikely the attachment of flexible cords thereto, the circuits should be so arranged that not more than 1,320 watts (or 32 sockets or receptacles) will be dependent on the final cut-out. Where a single socket or receptacle is used on a circuit the limitation of watts on the final cut-out should be the maximum capacity for which such socket or receptacle is approved.

Gas filled lamps should not be used in show windows or in other locations where inflammable material is liable to come in contact with lamp equipment except where used in connection with fixtures where temperature of any exposed portion of same does not exceed 200 degrees Fahrenheit.

They should not be used in connection with medium-

base sockets or receptacles if of above 200 watts nominal capacity nor with Mogul base sockets or receptacles if of above 1,500 watts capacity. If of above 100 watts they should not, if provided with a shade, reflector, fixture or other enclosure above the socket, be used in either medium or Mogul base type of sockets or receptacles having fibre or paper linings.

Fixtures within buildings should be wired with conductors having slow-burning or asbestos covering where the temperature to which wire is subjected at any point exceeds 120 degrees Fahrenheit. Where fixtures are placed outside of buildings rubber insulated wire should be used.

Insulation Resistance of Wiring Installation. The complete installation in any building should have a resistance between conductors and between conductors and ground not less than that given in the following table:

Up to	5	amperes.....	4,000,000 ohms
"	10	"	2,000,000 "
"	25	"	800,000 "
"	50	"	400,000 "
"	100	"	200,000 "
"	200	"	100,000 "
"	400	"	50,000 "
"	800	"	25,000 "
"	1,600	"	12,500 "

The test should be made with all cut-outs and safety devices in place. If the lamp sockets, receptacles, electroliers, etc., are also connected, only one-half of the resistances specified in the table will be necessary.

Decorative Lighting Systems. Decorative Lighting, by which is meant temporary work, should be done with an approved system, and the potential between the wires of any circuit should not be over 150 volts, nor should any group of lamps requiring more than 1,320 watts be dependent on one cut-out.

TRANSFORMERS

Oil Transformers. No transformers of this class should be placed inside of any building except central stations and sub-stations unless by special permission.

Air cooled transformers should not be placed inside of any building excepting central stations or sub-stations, if the highest voltage of either primary or secondary exceeds 550 volts, and, with the exception of

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TRANSFORMERS
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Size 4½x3½x2, Wt. 1½ Lbs.

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bell ringing and other signalling transformers, they should be so mounted that the case will be at a distance of at least one foot from combustible material or separated therefrom by non-combustible, non-absorptive, insulating material, such as slate, marble or soapstone. This will require the use of a slab or panel somewhat larger than the transformer.

Approved transformers for bell ringing and other signalling service may be used, provided all the wiring on the high voltage side is in accordance with the previous suggestions for inside wiring for low-potential systems. The rating of the high voltage winding must not be over 250 volts.

HIGH POTENTIAL SYSTEMS

550 to 3,500 Volts

Any circuit attached to any machine or combination of machines which develops a difference of potential between any two wires of over 550 volts and less than 3,500 volts, is considered as a high-potential circuit, and as coming under this class, unless an approved transforming device is used, which cuts the difference of potential down to 550 volts or less. For 550 volt motor equipments a margin of ten per cent. above the 550 volt limit at the generator or transformer is permissible without coming under high-potential systems.

All wires for high-potential systems should have an *approved* rubber-insulating covering, and should be always in plain sight, and never encased.

Such wires should be rigidly supported on glass or porcelain insulators, which raise the wire at least one inch from the surface wired over, and should be kept at least eight inches apart.

Rigid supporting requires under ordinary conditions, where wiring along flat surfaces, supports at least every four and one-half feet. If the wires are liable to be disturbed the distance between supports should be shortened.

In buildings of mill construction, mains of not less than No. 8 B. & S. gage, where not liable to be disturbed, may be separated about ten inches and run from timber to timber, not breaking around, and may be supported at each timber only.

This class of wiring should be protected on side walls from mechanical injury by a substantial boxing, retaining an air space of one inch around the con-

ductors, the boxing closed at the top (the wires passing through bushed holes) and extending not less than seven feet from the floor. When crossing floor timbers, in cellars, or in rooms where they might be exposed to injury, wire should be attached by their insulating supports to the under side of a wooden strip not less than one-half an inch in thickness.

ELECTRIC HEATING AND COOKING APPLIANCES

Every heater of more than six amperes or 660 watts capacity should be protected by a cut-out. Heaters of six amperes or 660 watts capacity, or less, may be grouped under the protection of a single set of fuses, provided the rated capacity of the fuses does not exceed ten amperes, or may be connected individually to lighting circuits when the normal load in use on the circuit at any time will not exceed 660 watts. Subdivided circuits of a heater need not be separately fused.

Each heater of more than six amperes or 660 watts capacity and each group of heaters not exceeding six amperes or 660 watts capacity should be controlled by a switch plainly indicating whether "on" or "off," located within sight of the heater and arranged to cut off all current from the heater. Where the capacity of the heater does not exceed fifteen amperes or 1,650 watts, an approved plug connector may be employed in lieu of a switch. Switches controlling subdivided circuits of a heater are not considered to take the place of the main switch.

The single pole switches on the individual units of electric ranges, etc., are not to be considered as taking the place of the main switch.

Flexible conductors for smoothing irons and sadirons, and for all devices requiring over 250 watts, should have an **approved** insulation and covering, consisting of a layer of rubber, a braided covering of asbestos and an outer braid enclosing either all the conductors as a whole or each conductor separately. See specifications for wire on page 117-128.

With portable heating devices **approved** plug connectors should be used, so arranged that the plug may be pulled out to open the circuit without leaving any live parts so exposed as to render likely accidental contact therewith. The connector may be located at either end of the flexible conductor or inserted in the conductor itself.

Smoothing irons, sadirons and other heating devices

that are intended to be applied to combustible articles should be provided with **approved** stands.

It is recommended that each such heating device or group of devices be used with approved signal or with an approved protective device.

Stationary heaters, such as radiators, ranges, plate warmers, etc., should be so located as to furnish ample protection between the device and surrounding combustible material.

The metal frame of such stationary heaters, etc., should preferably be grounded in accordance with the rules on grounding given on pages 101 to 108. When grounding is impracticable special permission, in writing, may be given, in which case the frame should be permanently and effectively insulated.

Every heating device should be provided with a name-plate, giving the maker's name and the normal capacity in volts and amperes, or in volts and watts.

Suggestions for Wiring Electric Ranges and Heating Devices

These specifications are not intended to give detailed instructions covering the methods to be used in wiring electric heating devices and ranges, but to furnish an outline of certain general arrangements and requirements which should be followed in every installation. Each job presents a different problem to the wireman, the details of which must be solved by the man on the ground, and the completed job made to conform with the general requirements given herewith.

Service connections should be made three wire, 110/220 volt, from pole line to house outlet, for all installations of 1,000 watts or over connected load. No. 6 copper wire should be the minimum size used for this class of service.

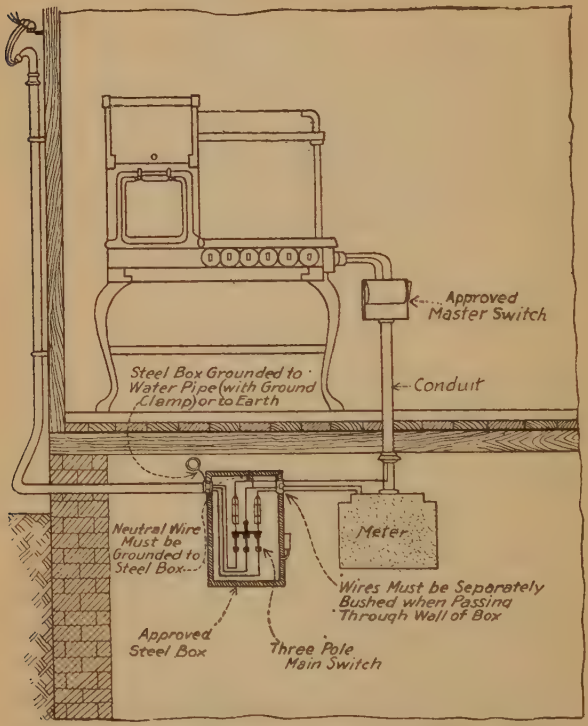
One-Family House. The wires from building outlet to main line switch should be installed in metal conduit. Three wires, No. 8 or larger, and 1-inch metal conduit should be used for all installations having a connected load of 1,000 watts or over.

In wiring new houses, when the connected load is unknown, the wireman should use his judgment as to whether the ultimate load will require greater carrying capacity than that of No. 8 wire and provide for the maximum in the original installation.

Flats and Apartment Houses. Mains feeding more

than one range should be large enough to supply the total load of all the ranges at the same time.

Where it is probable that the other tenants in the house will install electric ranges or heating devices, it will prove much cheaper to provide capacity for the


Approved Master Switch
Steel Box Grounded to Water Pipe (with Ground Clamp) or to Earth
Conduit
Neutral Wire Must be Grounded to Steel Box
Meter
Wires Must be Seperately Bushed when Passing Through Wall of Box
Approved Steel Box
Three Pole Main Switch

Simple range wiring diagram drawn in accordance with the regulations of the National Board of Fire Underwriters.

total ultimate load when making the first installation.

Range on First Floor of Residence or Flat. A new service connection should be installed, locating the meter and main line switch in the customary place and connecting existing lighting circuits to the new service.

The range circuit should then be extended from meter to range by the most direct route.

Range on the Second Floor of Apartment or Residence. The existing location of meters should be used wherever possible, installing the new circuit to the building outlet. Where necessary, the old meter loop should be taken out and connections to the existing lighting circuits brought to the new meter location. The main line switch should have sufficient capacity to care for the total load.

As apartment house meters are usually placed in the basement, it will be necessary to run a three-wire connection from building outlet to meter board, and a range circuit from this point to the range.

Unless the existing main line switch is a triple-pole-single-throw fused knife switch of an approved type and of sufficient capacity to carry the additional load, a new triple-pole-single-throw fused knife switch of 60 amperes or greater capacity should be installed in an approved metal cabinet or switch box. The outside legs of this switch should be equipped with fuses of rated ampere capacity equal to 150 per cent. of the connected load (but not above rated capacity of conductor). The neutral wire should be grounded on the load side of the switch but **should not be fused.**

Whenever possible the cut-outs for the lighting circuits should be enclosed in the same box with the main line switch. The accompanying cut (page —) illustrates the method of installing switches, meters, etc., recommended for standard practice.

All range circuits should be three wire No. 8 rubber-covered stranded wire **or larger** conductor depending upon the size of the installation and the distance from meter to load. The table given on page 98 should be used to determine the size of conductor which should be used in these circuits. Where conduit is used, the range circuit should be carried in approved metal conduit of not less than one inch inside diameter.

Three No. 8 or larger conductors should be used in all new houses where the size of range to be installed is unknown, but will not exceed 7,000 watts. When the length of circuit is great, ample size of conductor should be provided to avoid excessive voltage drop. Three No. 8 wires should be the minimum used, even though larger than at first required, as this will permit installing a larger range without changing the wiring. This increased cost would amount to only approxi-

mately five per cent. of the combined cost of ranges and wiring in most cases.

A master switch which clearly indicates whether it is open or closed, and a pilot light, where local requirements demand it, should be installed at a point within easy access of the range. This switch should be of the three-pole, fused type. It is essential to have a thoroughly safe installation; so use a safety switch which

WIRING TABLE

Two Per Cent. Drop

Load	No. 8	No. 6	No. 4	No. 2	No. 1
Watts	35 amp.	50 amp.	70 amp.	90 amp.	107 amp.
Distance in feet for 110/220 volt, three wire circuits					
1000	375				
1500	250				
2000	185	295			
2500	145	235			
3000	125	198	316		
3500	105	170	270		
4000	93	148	236		
4500	83	132	213		
5000	76	118	188	300	
5500	68	108	172	273	
6000	62	99	158	250	312
6500	58	92	145	231	289
7000	54	85	135	215	268
7500	50	79	126	200	250
8000		74	118	187	234
9000		66	105	166	208
10000		59	95	150	187
12000			79	125	156
15000				100	125
20000					94

is so constructed that there is no possibility of coming in contact with live parts in opening and closing or re-fusing the switch; or a triple-pole-single-throw knife switch should be installed in a steel cut-out box, so that the fuses are on the load side of the switch. This box should be installed at a minimum height of five feet above the floor. A caution label, warning against re-fusing the switch while in the closed position should be posted on the inside cover of the box, unless a type of safety enclosed switch is used which makes such danger impossible. The neutral wire should be grounded but not fused.

Where water heaters and ranges are supplied from the same circuit and their operation is controlled by a double throw or snap switch, this switch should be of an approved safety type.

The neutral wire of three wire circuits should be grounded at the main switch and at the range. All conduits should be grounded by means of No. 6 stranded copper wire fastened in an approved manner by approved ground clamps. The frame of the range should be thoroughly grounded. Joints or taps in the ground wire should all be soldered, and where the wire runs in an exposed position it should be protected from mechanical injury by means of raceway.

Ground connections should be made to the street side of the water meter wherever possible. Connections to pipes should be made with approved clamps and the pipe should be thoroughly cleaned of paint or dirt, so that a good connection is obtained.

It has been assumed that the range manufacturer has balanced the heating units connected to each leg of a three wire range. If this is not the case, the units should be reconnected, or the size of wire, switches and fuses increased to amply provide for the maximum current on the more heavily loaded side.

The consensus of opinion on the question of voltage seems to be that a balanced 110/220 volt, three wire service is the most desirable, even though balancing on a 110/220 volt system is difficult with only a few ranges.

The following data will aid in calculating the secondary distribution requirements for a typical range installation. In this calculation, it is assumed that the range and water heater installation will not exceed a maximum of 4½ kilowatts and will operate at 110 volts, thus requiring 40.9 amperes (non-inductive). Accordingly, the voltage drop will be R x 1 x feet, divided by 1,000.

With No. 4 wire, the voltage drop on the 4½ kw. installation, 1,000 feet distant, will equal 20.3 or 0.0203 volt drop per range foot. With No. 2 wire, the voltage drop on a 4½ kw. installation, 1,000 feet distant, would equal 12.76 volts or 0.01276 volt drop per range foot.

Allowing 10 volts drop (on 220 volt) at center of load on a 110/220 volt balanced three wire secondary (each range to be balanced with every other range installation on this service), each feeder from a transformer must have not in excess of 1,000 range feet on No. 4 wire at 220 volts and not more than 1,600 range feet on No. 2 wire at 220 volts.

On the straight 110 volt service, allowing five volts drop, the allowable range feet for No. 4 wire would be 315, and the allowable range feet for No. 2 wire would be 400. As an example of working out range distribution by means of the above data, the following will hold for a typical installation on 110-volt service from a balanced 110/220 volt three wire system.

Allowing six houses to the block (three on each side of the street) and the secondary wiring extending only two blocks in any direction from the transformer, and assuming 50 per cent. of these houses to have ranges installed, there would be 12 x 50 per cent. x 1 block distant equal 6 ranges x 300 feet, which is equal to 1,800 range feet. This exceeds 1,600 range feet, which is the allowance for this class of distribution on No. 2 wire. Therefore, the number of ranges must be cut down on this secondary feeder to five installations, which would then give 1,500 range feet, which is within the limit for No. 2 wire as specified.

The voltage should be tested when a range is installed, when additional ranges are connected to the same transformer and when the customer makes a complaint about the service. These tests should be made at the terminals of the range with all units switched "Full" and when the other ranges on the same transformer are in use. Current should be delivered to the range at the voltage specified on the nameplate of the range or units, but a variation of two or three volts is permissible.

Transformer capacity need not equal range demand because a range has so many units that its diversity factor is uncommonly high.

The following table may be used in determining the number of ranges which can safely be connected to a transformer, assuming each range has a maximum demand of 5,000 watts:

Number of Ranges	Size of Transformer
1	5 KVA
2	5 "
3	7½ "
4	7½ "
5	7½ "
6	7½ "
7	7½ "
8 to 11	10 "
12 to 20	15 "

GROUNDING

When protective grounding is required the suggestions given on the following pages are in accordance with the recommendations of the Committee on Grounding of the Electrical Committee of the National Fire Protection Association.

Where low potential circuits are grounded circuits should be so arranged that under normal conditions of service there will be no appreciable passage of current over the ground conductor.

When arresters, equipment, wire raceways, etc., are grounded, ground connections should be so disposed and underground piping systems so inter-connected, that there shall, under normal conditions, be no appreciable passage of current over the ground conductor.

Direct Current Systems. Point of Attachment. In three-wire direct-current systems the ground connection should be made on the neutral and at one or more supply stations, but not at individual services or within buildings served.

In two-wire direct-current systems the ground connection should be at one station only.

Alternating Current Systems. Point of Attachment. The ground connection for alternating current systems should be made at the building service or near the transformer (or transformers) either by direct ground connection, through water piping system or artificial ground, or by the use of a system ground wire to which are connected the grounded conductors of many secondary mains and which itself is effectually grounded at intervals that will fulfill, for any secondary utilizing the system ground wire, the resistance and current-carrying requirements for ground conductors.

Where the secondaries of transformers are supplying a common set of mains, fuses if installed should be installed only at such points as will not cause the loss of the ground connections after any fuses in the transformer circuits or mains have been blown.

Multiple grounds are preferable in most cases, but grounds, other than the single ground connection at the building service, should not be made to alternating current secondaries within the building served.

In single phase, three-wire systems, the ground should be on the neutral conductor.

In single phase, two-wire systems, the ground may be on either of the conductors.

In two-wire single phase, and in two or three-phase systems, the ground should be connected at that point of the system which brings about the lowest voltage from ground of unguarded current-carrying parts of connected devices and also permits of most convenient grounding. Where any phase of a two or three-phase system is used for lighting, that phase should be grounded and at the neutral conductor, if one is used.

Lightning Arresters and Ground Detectors. For lightning arresters and ground detectors, the ground connection should be at such a point that its ground conductor is as short and straight as practicable.

Equipment and Wire Raceways. For generators, motors, transformers, conduit, armored cable, metal raceways, etc., the point at which the ground conductor is attached should, if practicable, be readily accessible.

For conduit, armored cable or metal raceways the ground conductor should be as near as practicable to the point where the conductors in the conduit system concerned receive their supply.

When the service conduit is grounded, its ground conductor should be run direct from it to the ground connection. The interior conduit, armored cable or metal raceways, if well bonded to service conduit properly grounded, needs no additional ground connection.

Ground Conductors. In all cases, the ground conductor should be of copper or of other metal which will not corrode excessively under the existing conditions, and, if practicable, should be without joint or splice.

The insulation and installation of the ground conductor for circuits should comply with all the requirements for wires of the voltage of the circuit to which the ground conductor is attached and should have after January 1, 1919, an identifying covering. In all cases the ground conductor should be protected against mechanical injury. Protection for lightning arrester ground conductors should be of non-magnetic material unless the ground conductor is electrically connected to both ends of the protective device. In no case should an automatic cut-out be inserted in a ground conductor or connection, except in ground conductors for equipment where its operation will disconnect all leads connected to the equipment from the circuit conductors.

The ground conductor or conductors for circuits should, in general, have combined current capacity sufficient to insure the continuity and continued effectiveness of the ground connection under conditions of excess current caused by accidental grounding of any

normally ungrounded conductor of the circuit.

The ground conductor for a three-wire direct-current system should have a combined current capacity not smaller than the neutral wire to which it is attached.

The ground conductor for alternating current systems should not be smaller than No. 6 copper wire, nor smaller than one-fifth the current capacity of the wire to which it is attached, except that it need not be larger than No. 0 copper wire.

Lightning arrester ground connections should not be made to the same artificial ground (driven pipes or buried plates) as circuits or equipment, but should be well spaced and when practicable kept at least 20 feet from other artificial grounds.

For lightning arresters, the ground conductor should have a current capacity sufficient to insure the continuity and continued effectiveness of the ground connection under conditions of excess current caused by or following discharge of arrester.

No individual ground conductor should have a smaller current capacity than No. 6, B. & S. gage copper wire.

For the frames of electrical equipment the current capacity of the ground conductor should not be less than that provided by copper wire of the size indicated in the following table.

With portable equipment protected by fuses not greater than 15 amperes, No. 14 ground wire may be used.

Capacity of nearest cut-out protecting the equipment.	Required size of ground conductor.
0 to 100 amperes	No. 10, B. & S. gage
101 to 200 amperes	No. 6, B. & S. gage
201 to 500 amperes	No. 4, B. & S. gage
501 amperes and above	No. 2, B. & S. gage

The grounded circuit wires should not be used as ground wire for equipment, etc., and ground conductors from equipment, etc., should not be connected to grounded circuit wires.

If an armored cable system, a conduit system or a metal raceway system, consists of several separate sections, the sections should be bonded to each other, and the system grounded, or each section may be separately grounded.

The armor of conduits, cables, metal raceways and gas pipes should either be securely fastened in outlet boxes, junction boxes and cabinets, so as to secure

good electrical connection, or the separate sections, boxes and cabinets should be separately grounded.

Where short sections of conduit (or pipe of equivalent strength) are used for the protection of exposed wiring on side walls, the conduit or pipe need not be grounded.

Ground wires should be of copper or other metal which will not corrode excessively under the existing conditions. They should be at least equivalent to No. 10 B. & S. gage copper (where largest wire contained is not greater than No. 0, B. & S. gage) and need not be greater than No. 4 B. & S. gage (where the largest wire contained is greater than No. 0, B. & S. gage), and for service conduit the ground should not be less than No. 6 B. & S. gage copper.

The grounded circuit wires should not be used as ground wire for conduits, cables, metal raceways, and ground conductors from conduits, cables and metal raceways should not be connected to ground circuit wires.

If conduit, couplings or fittings having protective coating of non-conducting material, such as enamel, are used, such coating should be thoroughly removed from threads of both couplings and conduit and such surfaces or fittings where the conduit or ground clamp is secured, in order to obtain the requisite good connection. Grounded pipes should be clean of rust, scale, etc., at the place of attachment of ground clamp.

Ground Connection. The ground connection should be permanent and effective and be made as indicated below but always to water piping system if available.

The protective grounding of electrical circuits and equipment to water piping systems should always be permitted, since such grounding offers the most efficient protection to life and property and is not injurious to the piping systems.

For circuits, equipment and arresters at supply stations, connections should be made to all available active, continuous, metallic underground water piping systems between which no appreciable difference of potential normally exists and to one such system if appreciable differences of potential do exist between them. At other places connection should be made to at least one such system if available.

Where underground metallic piping systems are not available, other methods which will secure the desired permanence and conductance may be permitted.

When grounding conduit systems, in accordance with the instructions given on page 106 in this issue of Standard Wiring

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Ground connections to metallic piping system should be made on the street side of water meters, but connections may be made immediately inside building walls to secure accessibility for inspection and test. When water meters are located outside buildings or in concrete pits within buildings where piping connections are imbedded in concrete flooring, the ground connection may be made on the building side of the meters, if they are suitably shunted.

When the making of a ground to a piping system outside meter or other device would involve a long run, connection for equipment or wire runways may be made to the water piping system at a point near the part to be protected, provided there are no insulating joints in the pipe to prevent a good ground. In such cases care should be taken to electrically connect all parts of the piping system liable to create a hazard and to shunt the pipe system where necessary around meters, etc., in order to keep the connection with the underground piping system continuous.

Gas piping systems within buildings should not be used for grounding purposes except where water piping systems are not available and then only for grounding of equipment, metal moulding, raceways, etc., also excepting that gas piping need not be insulated from otherwise well-grounded electrical fixtures and where the making of another ground connection for a fixture would involve a long run and the fixture is therefore, of course, not within reach of plumbing or plumbing fixtures, the gas piping may for small fixtures be utilized as the sole ground connection. Where gas piping is so used it should be bonded to the water piping systems within the building at their points of entrance.

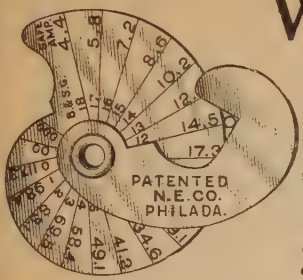
The ground connection to metallic piping systems should be made by means of an approved clamp which is bolted around the pipe after all rust and scale have been removed, or by means of a brass plug tightly screwed into pipe or fitting, or by other equivalent means.

The ground wire should be attached to the clamp or to the plug by means of solder or by an approved solderless connector (see page 6).

The point of connection should preferably be in plain sight and as readily accessible as possible.

Artificial grounds should be located where practicable below permanent moisture level. Each ground should present not less than four square feet surface

"NECO" Pocket Wire Gauge



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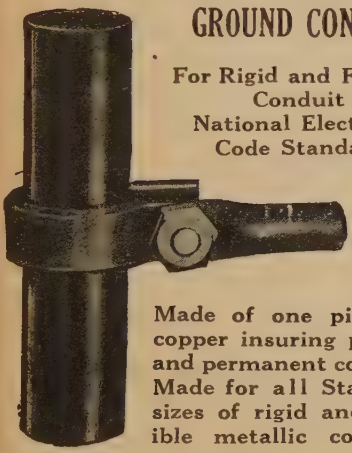

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to exterior soil. Areas where ground water level is close to the surface should be used when available.

Where ground plates are used they should be at least No. 16 Stubbs gage copper; when driven pipes are used they should be of galvanized iron and not smaller than one inch internal diameter; and when cast iron plates are used they should be at least one-quarter inch in thickness.

The combined resistances of the ground wires and connections of any grounded circuit, equipment, or lightning arrester should not exceed 3 ohms for water pipe connections, nor 25 ohms for artificial grounds where these are used. Where, because of dry or other high resistance soils, it is impracticable to obtain artificial ground resistance as low as 25 ohms, two such grounds six feet apart, if practicable, should be installed, and no requirement will be made as to resistance.

WATTHOUR METER INSTALLATION

Consumer's service watthour meter location, installation methods and the devices used to facilitate testing are questions of prime importance to both the consumer and the central station company supplying the service, and the point at which a watthour meter is to be placed should be carefully considered when laying out an installation.

General Installation Practice

The watthour meter assigned to each installation, (and in every case it is furnished and installed by the central station company furnishing the current, except where used on switchboards of isolated, or privately owned plants), should be suited to the voltage, frequency and character of the circuit and should be chosen with a view to obtaining the best adaptation to the local condition and to the load.

It is never advisable to install a watthour meter of greater capacity than is necessary to efficiently and economically register the load on which it usually operates. Over-metering not only increases the investment in meters, but results in an actual loss of revenue due to light load inaccuracy, as a watthour meter of small capacity will register a small load more efficiently than will a meter of larger capacity; the general tendency of watthour meters being to run slow, especially on light loads.

Watthour meters are generally most accurate when operating between 25 and 125 per cent. of their rated

current capacity. The meters for a given installation should be so chosen that the average load comes well within these limits and as near to its rated capacity as is possible without danger of damaging it or impairing its accuracy. Where the maximum load is of very short duration or occurs only at rare intervals, the preference should be toward smaller capacity meters. If, however, the duration of the light load is short compared with that of the heavy load, the watthour meter should be chosen to give the best accuracy under the latter conditions.

The connected load is generally taken as the sum of the ratings of all the apparatus connected to the circuit. The percentage of the connected load which is in use at any time is dependent upon the character of the installation and the business of the consumer, and it is at this point that the greatest uncertainty is encountered in choosing the proper size of watthour meter. In large installations, the question may be settled by a study of individual cases, but for small installations it is necessary to adopt general rules for various classes of consumers.

In the larger installations, local conditions frequently require special consideration to secure the most efficient results. The purpose for which the building is to be used and the business of the consumer are important factors, as the percentage of connected load used will vary largely, depending upon these factors.

Some companies decrease to some extent the difficulties of accurately metering an installation by limiting the character of the load to be connected to the same main and watthour meter; as, for instance, separate meters are required for light and power circuits; separate meters are required for signs, photographic arcs, charging sets, and other constant loads in excess of certain limits; separate meters are usually required for arc and incandescent lighting, and so on.

Selection of Meter Capacity. While common practice shows that on the average the kilowatt capacity of the watthour meters about equals the kilowatt capacity of the connected load, yet this is no doubt due to the large number of small capacity watthour meters installed on very small capacity installations; as, for instance, a five ampere watthour meter installed on two desk fans, or two or three lights. Such installations are of course greatly overmetered, but this is permissible for the reason that it is poor economy to purchase a meter of smaller capacity than five amperes.

Lighting Installations. In residences and apartments, watthour meters rated at from 35 to 50 per cent. of the connected load should generally be used, as seldom more than 50 per cent. of the lamps installed are used at any one time. Occasionally, during social and similar functions, the meters may be subjected to overloads, but the losses due to these overloads, which are usually infrequent, are more than compensated for by the greater accuracy obtained on the normal load. Most modern meters will withstand at least 100 per cent. overload without burning out.

Ordinary stores require meters rated at about 75 per cent. of the connected load, but large wholesale houses, where the lights are in use only when exhibiting goods, should be treated similarly to residences. It is not, however, customary to use watthour meters of lower than five amperes rating.

In small stores and similar places, where all the lamps connected are usually burning at one time, a watthour meter should be installed having a capacity about equal to the connected load. If, however, a certain number of the lamps are burned all night, it may be desirable to install a watthour meter of lesser capacity, the determining factor being the losses due to overload for a few hours considered against the losses due to light loads for the longer period.

An examination of the amount registered per month is sometimes an indication of the capacity of watthour meter to be installed. Such an examination may show that it is advisable to replace a meter by one of greater, or lesser capacity.

Where the load is practically constant, such as in restaurants and stores where all of the lamps are used at one time, signs without flashers and moving picture arcs (when metered separately from the auditorium lights), the capacity of the watthour meter should be approximately equal to the connected load.

Power Installations. For single motors the meter capacity is usually equal to the current rating of the motor. For elevator and crane motors, and for motors that are started and stopped frequently, some companies consider that the watthour meter should have a capacity of 25 or 50 per cent. greater than the nominal horsepower of the motor; in some instances even greater capacity may be advisable, depending upon the starting current and duty of the motor. When several motors are connected through the same watthour meter, the diversity factor of the load often is such

that a meter rated at much less than the combined ampere capacities of the motors may be used.

It may frequently be found advisable, after an installation is made, to determine the maximum and minimum demand, and to change the watthour meter, if necessary.

In large installations it may sometimes be advantageous to subdivide the load, metering the various divisions independently.

Service Meter Location. The question of service watthour meter location should be carefully considered in the first stages of laying out the installation. The continued accuracy of the meter is dependent to some extent on its location. A suitable location should be provided, not only for the sake of accuracy, but for convenience in reading and testing and operation.

In new buildings, especially in the case of large office buildings and apartment houses, special watthour meter closets of ample size should be provided in the halls or the basement, from which separate circuits run to the different suites.

Suggestions for Determining Location. Watthour meters should be installed at the nearest suitable location to the point where the service enters the building, and the circuit should be enclosed in continuous iron conduit from the service to the meter. See page —.

Meter boards are usually placed by the central station company, but when watthour meters are to be placed on switchboards, the consumer or contractor should do the necessary drilling, the proper template or drawing being furnished by the company upon request.

The requirements of a suitable meter location are given in the following clauses:

Accessibility. The watthour meter should be accessible with a minimum of annoyance to the tenants; should be so located that it may be easily read and should have sufficient space around it so that the tester has no difficulty in arranging and using his apparatus, or in inspecting and adjusting the meter.

The location of the watthour meters and the service cut-outs upon the premises of any person other than the one whose installation is controlled by them is to be avoided unless they are accessible at all times.

In cases where it is necessary to recess a meter in the wall, a meter cabinet should be provided, the walls and door of which should be made of some fireproof material. If metal is used, it should not be iron or

steel and must be covered with some form of insulation so as to prevent the possibility of a short circuit when connecting, disconnecting or testing meters.

Stray Fields. When a number of watthour meters are installed together, the distance between centers should not be less than 12 inches, to avoid stray field influences, from any of the meters or conductors in proximity.

All watthour meters should be installed not more than seven feet from the floor, on a stable support, in a clean, dry, safe place, free from vibration and magnetic disturbances.

Undesirable Locations. Among undesirable locations may be mentioned the following: In bedroom closets, bath or toilet rooms, attics, coal bins, elevator or ventilating shafts; near stoves or radiators, steam or gas piping, electric machinery; over doors, or on wooden partitions.

Moisture. The location selected should be free from moisture, and in this connection the possibility of future moisture resulting from "sweating" should be considered, i. e., a watthour meter should never be placed under a waterpipe, from which, as a result of "sweating," water may drip. When a damp location is unavoidable, a moisture-proof box should be provided to contain the meter.

Mechanical Injury. Watthour meters should be so located that they will not be exposed to mechanical injury. This requirement makes it undesirable to place a meter at a less distance than five or six feet from the floor. If it should be necessary to locate the meter near the floor, or in a position where it would be exposed to mechanical injury, a good stout box must be provided to contain the meter, and thus thoroughly protect it from any possible damage.

General Suggestions for Meter Installations

The central station company should have the right to inspect all circuits and apparatus at any time to insure that they are properly metered.

Each meter should be protected by its own sealed cut-out, placed between the meter and the point where the service enters the building.

No meter should be so connected as to include the registration of another meter, except for purposes of special investigation or where required by special conditions.

Where several meters are grouped together, the circuit in which each one is connected should be plainly

indicated, and all circuits should be carefully traced to insure that there is no error in the wiring whereby one consumer obtains current through another consumer's meter. This is especially important where the wiring is concealed, in which case the service and load wires should be tagged.

Open wiring, where used, should be arranged with a view to minimizing the likelihood of incorrect or improper connections. The wiring around the meter should be arranged neatly, without unnecessary crossing, and in such a manner as to minimize the liability to confusion between the different circuits.

Both sides of a two wire circuit should, where practicable, be carried through the meter. When this is done, the meter should be tested with the return bar in circuit, unless comparative tests with and without the return circuit show the given type and capacity of meter to be unaffected.

In two and three wire circuits, where a separate potential tap is used, precaution should be taken to prevent its becoming disconnected. The connecting wire should be as short as possible, should be accessible for inspection and should be soldered to the return or neutral circuit ahead of the service fuse. Where several branch circuits are supplied through the same meter, the potential tap should be carried back to the main line. Otherwise it may become disconnected by the opening of the fuse in one of the branch circuits.

In wiring three wire watthour meters care should be taken that both the current coils are connected in the outside wires and that they are not connected in opposition.

In wiring polyphase watthour meters, especially when used with potential and current transformers, great care is necessary to obtain the right connections. The meters should be wired in exact accordance with the manufacturer's diagram, and in addition the connections should be tested out to insure that the meter operates correctly.

The wiremen should leave a free end at least 18 inches long on each circuit to give ample wire for connection to the watthour meter.

Where no cut-outs are installed near the meter, the conduit for the service wiring and the conduit or raceway for the house wiring must terminate at a sufficient distance (six inches or more) from the meter to permit easily changing the connections for testing purposes.

Where watthour meters are installed in closets or

compartments, the conduit or raceway should terminate in plain view within the compartment. In a three wire circuit the neutral, and in a two wire circuit the grounded, side of the circuit should pass through the compartment.

In recent years much more attention has been given to the installation of watthour meters than formerly, in order to lessen the cost of maintenance and the possibility of tampering.

When open wiring is used, it is preferable to mount the watthour meter and the service cut-out on a suitable meter board of standard size, which is securely fastened to the wall. On brick, concrete, terra cotta or metal walls the boards must be set out from the wall, leaving an air space of at least seven-eighths of an inch back of the board. While the method of installing meters with open wiring, unprotected cut-outs and switches on both the service and the house sides of the meter is still practiced, yet it is no longer considered safe or satisfactory by many companies, especially in the larger cities.

Standardization of Installations. The best modern practice requires that the design of the installation should be compact and should be standard; or, rather, the several designs to meet different conditions should be standard, in order that all watthour meters can be erected in substantially the same manner. The design of the installation should also be of such a character that the several parts are interchangeable; no opportunities for tampering should be afforded and durability and flexibility should be combined in the design without excessive cost. All of the wiring and connections between the service and watthour meters should be enclosed in metal conduit or its equivalent, and all switches and cut-outs between the service and meters should be protected.

It is good practice in many instances to employ meter installation devices, which, together with the continuous conduit and the sealed service cut-outs, enclose and seal all the wiring around the watthour meter. Complete protection is thus provided for all unmetered parts of the circuit.

Generally a standard form of box is employed with metallic trim for fitting it to the various types of meter. In some cases the service cut-out is incorporated in the device.

WIRE AND WIRING DEVICES
Construction Specifications

All that the contractor or wireman need know about electric supplies, fittings or apparatus is that they are officially approved, or permitted to be used, and that they bear the maker's name plate or label, giving their capacities in volts, amperes, watts, etc. The Underwriters' requirements for their construction, however, are often found useful, and in getting up new designs for apparatus or supplies they are essential in determining the materials, dimensions and capacities to be followed to insure safety, durability, efficiency and their final adoption for use.

All new or doubtful devices, fittings and materials should be submitted to the Underwriters' Laboratories (see page 243) for examination and test before being introduced for use, and they must therefore comply with the following explicit specifications:

Bases. Bases on which live parts are mounted must be made of approved non-combustible, non-absorptive insulating material.

The design of the base must be such that, considering the material used, the base will withstand the most severe conditions liable to be met in practice.

Bases with an area of over 25 square inches must have at least four supporting screws. Holes for supporting screws must be so located or countersunk that there will be at least one-half inch space, measured over the surface, between the screw-head or washer and the nearest live metal part, and in all cases where between parts of opposite polarity must be countersunk.

Holes for supporting screws in link fuse cut-out bases must be kept outside the area included by the outside edges of the fuse terminals.

Nuts or screw-heads on the under side of the base must be countersunk and sealed with a waterproof compound.

Terminal Parts. Terminal parts by which wire connections are made must insure thoroughly good connections even under hard usage.

For currents above 30 amperes, lugs into which the connecting wires may be soldered or approved solderless connectors must be used.

For currents of 30 amperes and less the parts to which wiring connections are made must securely grip the conductors. Heavy clamps or screws with terminal

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The American Brass Co.

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Ansonia, Conn.

BENEDICT & BURNHAM BRANCH
Waterbury, Conn.

plates have upturned lugs or approved solderless connectors may be used.

The set screw form of contact will not be approved.

Clamps or lugs are not required when leads are provided as a part of a device.

Markings. The maker's name, trade-mark or other identification symbol must be placed on fittings and materials.

Markings giving voltage, current, wattage or other appropriate ratings are prescribed for many types of devices and must in general conform to the classifications given in this section.

Insulated Wires, Cables and Cords

General. All National Electrical Code Standard rubber-insulated wires, cables and cords shall be examined and tested at the factory and shall be labeled before shipment.

Wires, cables and cords of all kinds except weather-proof wire must have a distinctive marking the entire length of the coil so that they may be readily identified in the field. All wires, cables and cords must also be plainly tagged or marked as follows:

1. The maximum working pressure or voltage for which the wire was tested or approved. This may be omitted for slow burning, slow burning weather-proof and weather-proof wires.
2. The words "National Electrical Code Standard."
3. Name of the manufacturing company and, if desired, trade name of the wire.
4. Month and year when manufactured.
5. The proper type letter for the particular style of wire or cable as given in the following rules for each type of insulation.

Rubber-Covered Wire—Classification

R-Rubber covered single braided for voltage..	0-600
R15 Rubber covered single braided for maximum voltage	1500
R-25 Rubber covered single braided for maximum voltage	2500
R-35 Rubber covered single braided for maximum voltage	3500
R-50 Rubber covered single braided for maximum voltage	5000
R-70 Rubber covered single braided for maximum voltage	7000

R D, RD-15 Rubber covered double braided, etc.

R L, Rubber covered, single braided, leaded.

"AMERICAN BRAND"
WEATHERPROOF WIRE AND CABLES
HAS NO EQUAL

BARE & INSULATED WIRE & CABLE

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SERVICE & QUALITY

TRIPLE BRAID

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Twenty-First, Sangamon & Morgan Sts.

Long Distance Telephone, Canal 7470

CHICAGO, ILL.

R D L, Rubber covered, double braided, leaded.
A C, Wires for use in armored cable.
A C L, Leaded wires for use in armored cable.

Conductors. No individual conductor, whether solid or stranded, shall be less than No. 14 B. & S. gage in nominal size.

All conductors and the individual wires of stranded conductors shall be tinned.

Insulation. Conductors shall be insulated for their entire length with a properly applied and properly vulcanized rubber compound.

The insulation must be of the nominal thickness given in the following table, the requirements of which vary according to the sizes of conductors and the maximum working pressure.

Table of thickness of rubber insulation for rubber covered wires and cables in 64th inches:

Size of Conductor	Type Letters	R	R-15	R-25	R-35	R-50	R-70
American or B. & S. Gauge	For Working Pressures Not Over	600 Volts.	1500 Volts.	2500 Volts.	3500 Volts.	5000 Volts.	Volts. 7000
14 to 8.....		3	4	6	8	12	16
7 to 2.....		4	5	6	8	12	16
1 to 0000 C. M.		5	6	7	8	12	16
225,000 to 500,000		6	7	8	9	12	16
525,000 to 1,000,000 ...		7	8	9	10	12	16
Over 1,000,000.		8	9	10	11	14	18

Coverings. All single conductor rubber insulated wires and cables must have a covering of fibrous material applied directly to the surface of the insulating wall.

For any single conductor wire there shall be at least one braid for sizes from No. 14 to and including No. 8. For all single conductor cables larger than No. 8 there must be at least two braids or a tape and a braid.

For twin wires and twisted pair wires and for all multiple conductor cables there shall be a fibrous covering on each individual wire and in addition a braid enclosing the bunched conductors.

For certain special service conditions, one or more additional coverings of fibrous material or of lead are required.

Fibrous coverings may be either braid or tape, but tape shall not be used for the outer covering. All

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INSULATED WIRE

Atlantic Insulation is notable for its dependability and maximum service.

DOLPHIN, code; TRITON, high grade; and NEPTUNE, extra high grade, are three widely known and extensively used Atlantic Wires.

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T. C. Coleman & Son,
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PITTSBURGH
W. A. McCoombs & Co.,
Union Arcade Bldg.

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Rank & Goodell,
Merchants Bank Bldg.

braids must be impregnated with a moisture-proof compound.

Lead coverings may be applied to single or multiple conductors. Lead covered multiple conductor cable with more than two conductors must, in all cases, have the conductors spirally laid.

In all cases, the individual conductors in lead covered cable must have a fibrous covering and, except for two conductor cables, with conductors parallel, there must be a fibrous covering over bunched conductors.

Fexible Cords. Each conductor in a flexible cord must have a carrying capacity not less than that of a No. 18 B. & S. gage wire.

The insulation must consist of properly applied and properly vulcanized rubber compound of the nominal thickness given in the following table:

B. & S. Gage	Thickness, Inches
18 and 16	1/32
14 to 8	3/64

Each conductor must be covered with a tight, close wind of fine cotton or some other method must be employed to prevent a broken strand puncturing the insulation.

Cords of the several types are described in the table on the following page.

(Type Letters C, CB and CC.) In these classes are included flexible cords which under usual conditions hang freely in air.

(Type Letters PO and PS.) These cords are for use only in offices, dwellings or similar places where not liable to rough usage.

For Type PO the conductors may be either laid parallel or twisted together.

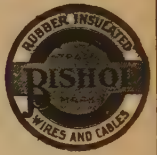
Type PS cord may be made only with conductors of No. 18 or No. 16 B. & S. gage and may have insulation only 1/64-inch in thickness.

(Type Letter T.) Shall consist of not more than three conductors, each not exceeding No. 4 B. & S. gage, twisted together and with a filler. The insulation on each conductor of No. 6 to No. 4 B. & S. gage shall be 1/16-inch in thickness.

BISHOP

RUBBER INSULATED

WIRES AND CABLES



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Lead Encased Cables

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Flexible Cables

Railway Signal Wire

Car Wire and Cables

Automobile Lighting, Starting and Ignition Cable

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420 E. 25ST., NEW YORK

Use	Type Letter	Trade Name	Braid on Each Conductor	Reinforcement or Filler	Outer Cover
Pendants Dry Places	C	Lamp Cord	Glazed Cotton or Silk		
Pendants Damp Places	CB CC	Brewery Cord Canvasite Cord	Cotton Wp. " "		Cotton Wp.
Portable Dry Places	P PO PS CA PA	Reinforced Cord Parallel Cord Special Reinf. Cord Armored Cord Armored Reinf. Cord	Cotton " " "	Rubber Jacket Rubber Jacket Rubber Jacket	Glazed Cot. or Silk " " Armor Glazed Cotton and Armor
Portable Damp Places	P Wp. Pk Wp. PA Wp.	Reinforced Cord Wp. Packinghouse Cord Armored Reinf. Cord Wp.	Cotton " "	Rubber Jacket Filler Rubber Jacket	Cotton Wp. 2 Cotton both Wp. Cotton Wp. and Armor
Theatre Stages	T	Stage Cable	Cotton Wp.	Filler	2 Cotton both Wp.
Theatre Borders	B	Border Light Cable	Cotton Wp.		2 Cotton both Wp.
Elevator Lighting and Control	E	Elevator Cable	Cotton	Rubber Jacket and of	1 or more Cotton both Wp. 3 Cotton, outer one Wp.

Rubber Covered Wire—Solid, Stranded, Flexible and Extra Flexible Conductor.

Lamp Cords, Reinforced Cords, Heater Cord, Brewery Cord, Canvasite Cord, Packinghouse Cord.

Deck Cable, Stage Cable, Border Light Cable, Charging Cable and other portable cables with special tough outer covering.

Elevator Lighting Cable, Elevator Operating Cable, Elevator Annunciator Cable.

Railway Signal Wires, Telephone Wire, Flameproof Wires, Switchboard Wire, High Voltage Wires.

Automobile Ignition, Lighting and Starting wires, Airplane Motor Ignition Wire, Special Wires used in Radio Work.

Boston Insulated Wire & Cable Co.

MAIN OFFICE AND FACTORY
DORCHESTER DISTRICT - BOSTON, MASS
CANADIAN FACTORY
BOSTON INS. WIRE & CABLE CO., LTD. HAMILTON, ONT

(Type Letter E.) Conductors for elevator lighting cable shall not be smaller than No. 14 and for elevator control cables not smaller than No. 16 B. & S. gage.

Fort Portable Heating Apparatus: (Type Letter H.) This cord is for use with all smoothing and sadirons and with other heating devices requiring over 250 watts.

The covering may consist of a layer of rubber or other **approved** material, a braided covering of asbestos and an outer braid enclosing either all the conductors as a whole or each conductor separately.

Other types of coverings must be submitted for special examination and approval before being used.

Fixture Wire. Fixtures may be wired with **approved** flexible cord or **approved** rubber covered wire.

Conductors. May be either solid or stranded and must not be smaller than No. 18 B. & S. gage.

If stranded conductor is used each conductor must be covered with a tight close wind of fine cotton or some other method must be used to prevent a broken strand puncturing the insulation. Solid conductors must be tinned.

Insulation. The insulation must consist of properly applied and properly vulcanized rubber compound.

The thickness of insulation shall not be less than 1/64-inch for No. 18 B. & S. gage wire and not less than 1/32-inch for No. 16 B. & S. gage.

Coverings. Must be of braid at least 1/64-inch in thickness sufficiently tenacious to withstand abrasion of being pulled into fixtures.

Armored Cable and Cord. The conductors must comply with the requirements for rubber covered wires or cords of the specified types and construction.

The cable or cord must have a distinctive marker its entire length.

Slow Burning Weatherproof Wires. This wire is not as burnable as "weather-proof" nor as subject to softening under heat. It is not suitable for outside work.

The insulation must consist of two coatings, one to be fireproof and the other weather-proof. The fireproof coating must be on the outside and must comprise about six-tenths of the total thickness of the wall.

The thickness of the completed covering shall be not less than that specified for rubber insulation of 0-600 volt rubber covered wires.

Slow Burning Wire. This insulation is especially useful in hot, dry places where ordinary insulations would perish, and where wires are bunched as on the back of a large switchboard or in a wire tower, so

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WIRES AND CABLES

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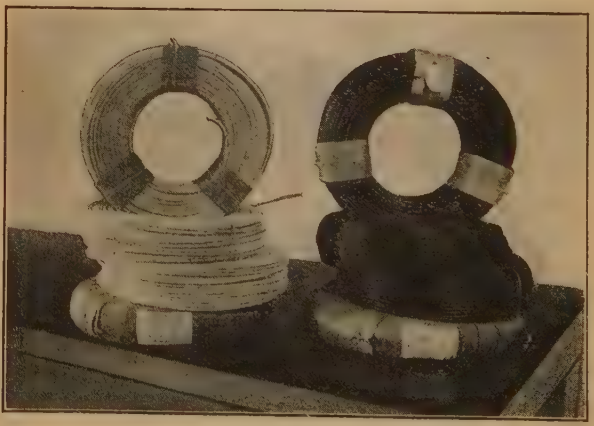

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MONADNOCK BLDG., CHICAGO, ILL.

FACTORY, SYCAMORE, ILL.

that the accumulations of rubber insulation would result in an objectionable large mass of highly inflammable material.

Slow burning conductors especially designed and approved for use in fixtures need not necessarily comply with the following requirements:

The insulation must consist of three braids of cotton or other thread, all the interstices of which must be filled with material having fire resisting and insulating properties. Its surface must be finished smooth and hard.

The thickness of the completed covering shall be not less than that specified for the rubber insulation of 0-600 volt rubber covered wires.

Weatherproof Wire. This wire is for use outdoors, where moisture is certain, and where fireproof qualities are not necessary.

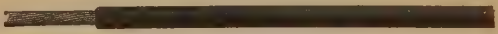
The insulating covering shall consist of at least three braids, all of which must be thoroughly saturated with a dense moisture-proof compound.

The thickness of the completed covering shall be not less than that specified for the rubber insulation of 0-600 volt rubber covered wires.

A convenient type of pocket wire gauge, one-half actual size, for measuring wire from No. 18 to No. 000 B. & S. gauge. On the front is given the safe carrying capacity of copper wires in amperes, and on the reverse side the approximate decimal equivalent of the various sizes of wires.

Deltabeston Wires

MAGNET WIRE.—Covered with pure asbestos fibre in a smooth flexible layer, which will not crack nor break even when sharp bends are made. Tough, moisture-proof and indestructible under any commercial temperature.



FIXTURE WIRE.—For installations where temperature makes rubber covered wires impracticable, this smooth, flexible, tenacious asbestos fibre covering will give best protection and longest service. Especially adapted for wiring Type C Fixtures.

FIXTURE WIRE.—Same construction as the above, with the addition of a silk covering over the asbestos fibre to give a neat, attractive appearance where wiring of fixtures is exposed to view. Made in single, parallel and twisted pair conductors.

HEATER CORD.—Asbestos insulated throughout; will not burn nor deteriorate like rubber. The special application of the asbestos fibre re-enforces the strands of the conductor against their breaking and puncturing the insulation. The occurrence of short circuits is thereby eliminated and longer life obtained.

STOVE WIRE.—Furnishes perfect wiring for electric stoves and ranges, in and around ovens and boiler rooms. Insulated with especially treated asbestos fibre and a tightly braided asbestos covering.

MOVING PICTURE CABLE.—A very flexible conductor having a wall of asbestos fibre and a braided asbestos covering; moisture-proof; widely used where wires are subjected to high temperatures —projectors, searchlights, railroad controllers, cranes, etc.

Approved by the Underwriters' Laboratories, Inc.

D & W Fuse Company

Providence, R. I.

"RUBBER-COVERED" INSULATED WIRE— SOLID CONDUCTORS.

Size B. & S.	Diam. of Conductors, Mils.	Circular, Mils.	Single Braid		Double Braid	
			Diam. Over All.	Weight Per 1,000 Ft.	Diam. Over All.	Weight Per 1,000 Ft.
0000	460	211600	47/64	809	55/64	832
000	410	167803	11/16	666	13/16	690
00	365	133079	5/8	546	47/64	568
0	325	105524	19/32	453	45/64	476
1	289	83695	33/64	355	5/8	376
2	258	66373	29/64	275	9/16	295
3	230	52634	27/64	227	33/64	245
4	204	41743	25/64	186	15/32	200
5	182	33102	23/64	160	7/16	170
6	162	26250	5/16	128	25/64	135
8	129	16510	17/64	80	11/32	86
10	102	10382	15/64	58	19/64	64
12	81	6530	7/32	43	9/32	48
14	64	4107	13/64	32	1/4	37
16	51	2583	3/16	20	.....	...
18	40	1624	11/64	16	.....	...
19	36	1288	5/32	15	.....	...
20	32	1022	9/64	14	.....	...

NATIONAL ELECTRICAL CODE WIRE OF ALL KINDS

Insulated Telephone Wires

"Ajax" Copper Clad
Standard Copper Clad
H. D. Copper Drop Wire
Flame Proof Wire
Jumper Wire
Bridle Wire
Interior Wire

Automobile Wires

Charging Cable
Ignition Wire
Starter Cable
Lighting Wire
Horn Wire

Miscellaneous Wires

Battery Wire
Border Light Cable
Brewery Cord
Canvasite Cord
Deck Cable
Fixture Wire
Gas Engine Cable
Lamp Cord
Mining Machine Cable
Elevator Cable
Door Bell Wire

INSULATED WIRES FOR ALL ELECTRICAL USES

DETROIT INSULATED WIRE CO.

Detroit, Mich.

"RUBBER-COVERED" INSULATED WIRE—STRANDED CONDUCTORS.

Size B. & S.	Concentric Strands No. Wires.	Concentric Strands Diam. Each.	Diam. of Conductors, Mils.	Single Braid Diam. Over All.	Single Braid Weight Per 1,000 Ft.	Double Braid Diam. Over All.	Double Braid Weight Per 1,000 Ft.
2000000 C.M.	91	148	1650	2	7246	2 9/64	7385
1750000 C.M.	91	139	1550	1 29/32	6394	2 3/64	6525
1500000 C.M.	91	128	1430	1 51/64	5539	1 15/16	5658
1250000 C.M.	91	117	1308	1 43/64	4678	1 13/16	4783
1000000 C.M.	61	128	1166	1 1/2	3754	1 5/8	3849
900000 C.M.	61	121	1104	1 7/16	3404	1 9/16	3491
800000 C.M.	61	115	1049	1 3/8	3058	1 1/2	3138
750000 C.M.	61	111	1013	1 11/32	2881	1 15/32	2956
700000 C.M.	61	107	978	1 5/16	2709	1 7/16	2880
650000 C.M.	61	103	943	1 17/64	2534	1 25/64	2600
600000 C.M.	61	99	906	1 1/4	2355	1 3/8	2418
550000 C.M.	61	95	870	1 13/64	2182	1 21/64	2240
500000 C.M.	37	116	821	1 1/8	1959	1 1/4	2010
450000 C.M.	37	110	779	1 3/32	1791	1 7/32	1840
400000 C.M.	37	104	738	1 3/64	1608	1 11/64	1650
350000 C.M.	37	97	688	1	1431	1 1/8	1468
300000 C.M.	37	90	639	15/16	1250	1 1/16	1285
250000 C.M.	37	82	583	7/8	1071	1	1103
0000	19	.105	530	13/16	899	15/16	942
000	19	.094	475	3/4	740	7/8	782
00	19	.083	425	45/64	607	13/16	647
0	19	.074	380	5/8	492	47/64	526
1	19	.066	329	9/16	387	43/64	417
2	19	.059	296	1/2	303	39/64	329
3	7	.086	263	29/64	249	9/16	272
4	7	.077	233	7/16	204	17/32	227
5	7	.068	209	13/32	175	1/2	192
6	7	.061	185	3/8	141	29/64	156

HABIRSHAW

"Proven by the test of time"

Insulated Wire and Cable

The Standard of Quality

in

Rubber Insulated Cables
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- Intermediate
- 30% Hevea
- Park Cables

Armored Cables

Paper and Varnished Cambric Insulated Cables

Manufactured by
Habirshaw Electric Cable Co.
Incorporated
10 East 43rd Street, New York

Distributed by
Western Electric Company
Incorporated
Offices in All Principal Cities

"WEATHERPROOF" INSULATED WIRE

—SOLID CONDUCTORS.

Size B. & S.	Weatherproof Wire			Slow-Burning Weatherproof Wire			Slow-Burning Wire		
	Wgt. per 1,000 Ft.	Wgt. per Mile.	Diameter Over All.	Wgt. per 1,000 Ft.	Wgt. per Mile.	Diameter Over All.	Wgt. per 1,000 Ft.	Wgt. per Mile.	Diameter Over All.
0000	767	4050	25/32	862	4550	3/4	925	4890	3/4
000	630	3320	47/64	710	3750	45/64	760	4020	45/64
00	502	2650	39/64	562	2970	37/64	600	3170	37/64
0	407	2150	9/16	462	2440	17/32	495	2610	17/32
1	316	1670	1/2	340	1800	15/32	365	1930	15/32
2	260	1370	15/32	280	1480	7/16	320	1690	7/16
3	200	1050	27/64	230	1220	13/32	270	1425	13/32
4	164	865	25/64	190	1000	3/8	220	1160	3/8
5	134	710	11/32	155	820	11/32	190	1000	11/32
6	112	590	5/16	127	670	5/16	160	845	5/16
8	75	395	17/64	85	450	7/64	100	530	17/64
10	53	280	1/4	60	315	1/4	80	420	1/4
12	35	185	7/32	42	220	7/32	55	290	7/32
14	25	130	3/16	30	160	3/16	40	210	3/16
16	14	75	5/32	15	80	5/32	18	95	5/32
18	11	58	1/8	12	63	1/8	14	75	1/8

INDIANA RUBBER AND INSULATED WIRE CO.

Paranite Rubber Covered Wires and Cables

IF IT'S PARANITE IT'S RIGHT

More Than Code Requires

Underground, Aerial, Submarine and inside use

Telephone, Telegraph and Fire Alarm Cables

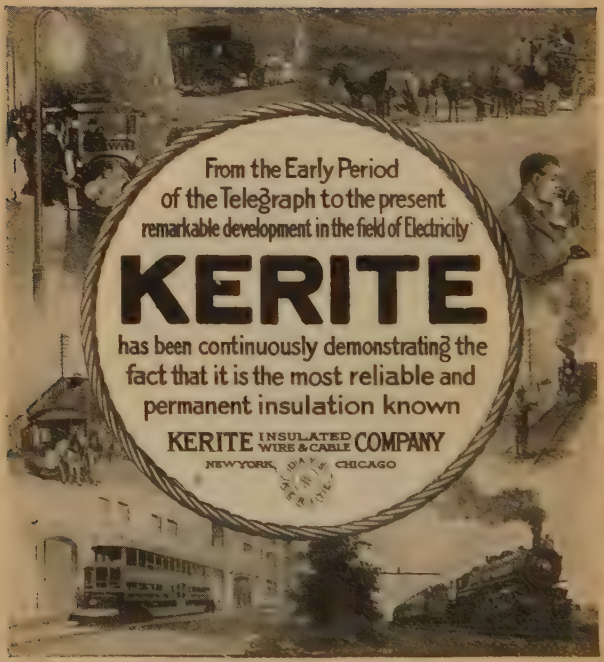
Factory and General Offices, Jonesboro, Ind.

Chicago Offices, 210 So. Desplaines St. Chicago, Illinois.

Eastern Representatives, THOMAS & BETTS CO. 63 Vesey St., New York

"WEATHERPROOF" INSULATED WIRE—STRANDED CONDUCTORS

Size B. & S.	Weatherproof Wire			Slow-Burning Weatherproof Wire			Slow-Burning Wire		
	Wgt. per 1,000 Ft.	Wgt. per Mile.	Diameter Over All.	Wgt. per 1,000 Ft.	Wgt. per Mile.	Diameter Over All.	Wgt. per 1,000 Ft.	Wgt. per Mile.	Diameter Over All
2000000 C.M.	7000	37000	2 1/8	7300	38500	2	7800	41000	2
1750000 C.M.	6200	32750	2	6550	34600	1 7/8	6900	36300	1 7/8
1500000 C.M.	5400	28500	1 7/8	5675	30000	1 3/4	6000	31800	1 3/4
1250000 C.M.	4500	23800	1 3/4	4780	25200	1 11/16	5000	26400	1 11/16
1000000 C.M.	3675	19400	1 21/32	3860	20400	1 39/64	3980	21000	1 39/64
900000 C.M.	3330	17600	1 39/64	3520	18600	1 9/16	3640	19200	1 9/16
800000 C.M.	3000	15800	1 9/16	3180	16800	1 33/64	3280	17300	1 33/64
700000 C.M.	2650	14000	1 15/32	2820	14900	1 27/64	2920	15400	1 27/64
600000 C.M.	2235	11800	1 21/64	2350	12400	1 9/32	2460	13000	1 9/32
500000 C.M.	1900	10000	1 1/4	1990	10500	1 13/64	2080	11000	1 13/64
450000 C.M.	1725	9100	1 3/16	1820	9600	1 9/64	1900	10000	1 9/64
400000 C.M.	1550	8200	1 9/64	1650	8700	1 3/32	1700	9000	1 3/32
350000 C.M.	1345	7100	1	1440	7600	1 1/32	1500	7900	31/32
300000 C.M.	1175	6200	31/32	1270	6700	15/16	1310	6900	15/16
250000 C.M.	985	5200	29/32	1060	5600	7/8	1120	5900	7/8
0000	800	4220	55/64	900	4750	53/64	940	5070	53/64
000	653	3450	51/64	735	3880	49/64	784	4150	49/64
00	522	3760	43/64	583	3080	41/64	625	3300	41/64
0	424	2240	39/64	480	2530	37/64	510	2709	37/64
1	328	1735	35/64	355	1870	33/64	380	2000	33/64
2	270	1425	33/64	290	1540	31/64	335	1770	31/64
3	206	1090	15/32	240	1270	29/64	280	1480	29/64


From the Early Period
of the Telegraph to the present
remarkable development in the field of Electricity
KERITE
has been continuously demonstrating the
fact that it is the most reliable and
permanent insulation known
KERITE INSULATED WIRE & CABLE COMPANY
NEW YORK CHICAGO

WIRE TABLE. STANDARD ANNEALED COPPER.

Gauge No. B. & S.	Diameter in Mils at 20° C.	Cross Section Circular Mils	Ohms per 1000 Feet *		
			0° C. (=32° F)	20° C. (=68° F)	50° C. (=122° F)
[illegible]	460.9	211 600.	0.045 16	0.049 61	0.054 79
[illegible]	409.6	167 800.	.056 93	.061 49	.069 99
00	364.8	133 100.	.071 81	.077 93	.087 12
0	324.9	105 500.	.09056	.09827	.1099
1	289.3	83 690.	.1142	.1239	.1385
2	257.6	66 370.	.1440	.1563	.1747
3	229.4	52 640.	.1816	.1970	.2203
4	204.3	41 740.	.2289	.2485	.2778
5	181.9	33 100.	.2887	.3133	.3502
6	162.0	26 250.	.3640	.3951	.4416
7	144.3	20 820.	.4590	.4982	.5569
8	128.5	16 510.	.5788	.6282	.7023
9	114.4	13 090.	.7299	.7921	.8855
10	101.9	10 380.	.9203	.9988	1.117
11	90.74	8234.	1.161	1.260	1.408
12	80.81	6530.	1.463	1.588	1.775
13	71.96	5178.	1.845	2.003	2.239
14	64.08	4107.	2.327	2.525	2.823
15	57.07	3257.	2.934	3.184	3.560
16	50.82	2583.	3.700	4.016	4.489
17	45.26	2048.	4.666	5.064	5.660
18	40.30	1624.	5.883	6.385	7.138
19	35.89	1288.	7.418	8.051	9.001
20	31.96	1022.	9.355	10.15	11.35
21	28.46	810.1	11.80	12.80	14.31
22	25.35	642.4	14.87	16.14	18.05
23	22.57	509.5	18.76	20.36	22.76
24	20.10	404.0	23.65	25.67	28.70
25	17.90	320.4	29.82	32.37	36.18
26	15.94	254.1	37.61	40.81	45.63
27	14.20	201.5	47.42	51.47	57.53
28	12.64	159.8	59.80	64.90	72.55
29	11.26	126.7	75.40	81.82	91.48
30	10.03	100.5	95.06	103.2	115.4
31	8.928	79.70	119.9	130.1	145.5
32	7.950	63.21	151.2	164.1	183.4
33	7.080	50.13	190.6	206.9	231.3
34	6.305	39.75	240.4	260.9	291.7
35	5.615	31.52	303.1	329.0	367.8

* Resistance at the stated temperatures of a wire whose length is 1000 feet at 20° C. (Bureau of Standards)

NACONCA PRODUCTS

Bare Copper Wire and Cable

Weatherproof Insulated Copper Wire and Cable

Cotton Covered Magnet Wire

Office and Annunciator Wire

Paper Insulated Lead Encased Cables for the transmission of power

NATIONAL CONDUIT & CABLE COMPANY, Inc.

General Offices and Mills:

HASTINGS-ON-HUDSON, N. Y.

Sales Offices:

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New York, N. Y.

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Boston, Mass.

1530 Chestnut Street
Philadelphia, Pa.

209 South LaSalle Street
Chicago, Ill.

816 Hippodrome Building
Cleveland, Ohio

311 Commercial Bank Building
New Orleans, La.

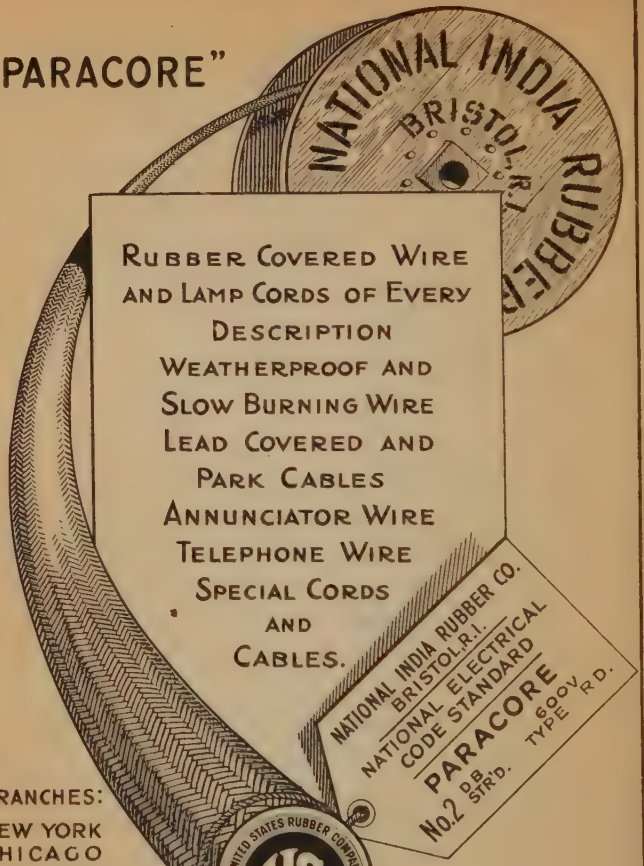
639 Mission Street
San Francisco, Calif.

417 East Third Street
Los Angeles, Calif.

Gage No. B. & S.	Diameter in Mils at 20° C	Pounds per 1000 Feet	Feet per Ohm *		
			0° C (=32° F)	20° C (=68° F)	50° C (=122° F)
0000	460.0	10.5	22 140.	20 400.	18 250.
000	409.6	807.9	17 560.	16 180	14 470.
00	364.8	102.8	13 930.	12 830.	11 480.
0	324.9	319.5	11 040.	10 180	9103.
1	289.3	253.3	8758.	8070.	7219.
2	257.6	200.9	6946.	6400.	5725.
3	229.4	159.3	5508.	5075.	4540.
4	204.3	126.4	4368.	4025.	3600.
5	181.9	100.2	3464.	3192.	2855.
6	162.0	79.46	2747.	2531.	2264.
7	144.3	63.02	2179.	2007.	1796.
8	128.5	49.98	1728.	1592.	1424.
9	114.4	39.63	1370.	1262.	1129.
10	101.9	31.43	1087.	1001.	895.6
11	90.74	24.92	861.7	794.0	710.2
12	80.81	19.77	683.3	629.6	563.2
13	71.96	15.68	541.9	499.3	446.7
14	64.08	12.43	429.8	396.0	354.2
15	57.07	9.858	340.8	314 0	280.9
16	50.82	7.818	270.3	249.0	2 2 8
17	45.26	6.200	214.3	197.5	176.7
18	40.30	4.917	170.0	156.6	140.1
19	35.89	3.899	134.8	124.2	111 1
20	31.96	3.092	106.9	98.50	88.11
21	28.46	2.452	84.78	78.11	69.87
22	25.35	1.945	67.23	61.9	55.41
23	22.57	1.542	53.32	49.13	43.9
24	20.10	1.223	42.28	38.96	34.85
25	17.90	0.9699	33.53	30.90	27 6
26	15.94	.7692	26.59	24.50	21.92
27	14.20	.6100	21.09	19.43	17.38
28	12.64	.4837	16.72	15.41	13.78
29	11.26	.3836	13.26	12.22	10.93
30	10.03	.3042	10.52	9.69	8.669
31	8.928	.2413	8.341	7.683	6.875
32	7.950	.1913	6.614	6.095	5.452
33	7.080	.1517	5.245	4.833	4.323
34	6.305	.1203	4.160	3.83	3.429
35	5.615	.095 42	3.299	3.040	2.719

* Length at 20° C of a wire whose resistance is 1 ohm at the stated temperatures. (Bureau of Standards).

"PARACORE"



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WIRE DIVISION

United States Rubber Company

BRISTOL, RHODE ISLAND.

WIRE TABLE, STANDARD ANNEALED COPPER. —CONTINUED.

Gage No. B. & S.	Diameter in Mils at 20° C	Ohms per Pound*		
		0° C (=32° F)	20° C (=68° F)	50° C (=122° F)
0000	460.0	0.000 070 51	0.000 076 52	0.000 085 54
000	409.6	.000 1121	.000 1217	.000 1360
00	364.8	.000 1783	.000 1935	.000 2163
0	324.9	.000 2835	.000 3076	.000 3439
1	289.3	.000 4507	.000 4891	.000 5468
2	257.6	.000 7166	.000 7778	.000 8695
3	229.4	.001 140	.001 237	.001 383
4	204.3	.001 812	.001 966	.002 198
5	181.9	.002 881	.003 127	.003 495
6	162.0	.004 581	.004 972	.005 558
7	144.3	.007 284	.007 905	.008 838
8	128.5	.011 58	.012 57	.014 05
9	114.4	.018 42	.019 99	.022 34
10	101.9	.029 28	.031 78	.035 53
11	90.74	.046 56	.050 53	.056 49
12	80.81	.074 04	.080 35	.089 83
13	71.96	.1177	.1278	.1428
14	64.08	.1872	.2032	.2271
15	57.07	.2976	.3230	.3611
16	50.82	.4733	.5136	.5742
17	45.26	.7525	.8167	.9130
18	40.30	1.197	1.299	1.452
19	35.89	1.903	2.065	2.308
20	31.96	3.025	3.283	3.670
21	28.46	4.810	5.221	5.836
22	25.35	7.649	8.301	9.280
23	22.57	12.16	13.20	14.76
24	20.10	19.34	20.99	23.46
25	17.90	30.75	33.37	37.31
26	15.94	48.89	53.06	59.32
27	14.20	77.74	84.37	94.32
28	12.64	123.6	134.2	150.0
29	11.26	196.6	213.3	238.5
30	10.03	312.5	339.2	379.2
31	8.928	497.0	539.3	602.9
32	7.950	790.2	857.6	958.7
33	7.080	1256.	1364.	1524.
34	6.305	1998.	2168.	2424.
35	5.615	3177.	3448.	3854.

* Bureau of Standards.

TRADE MARK.
REG. U. S. PATENT OFFICE

THE STANDARD FOR RUBBER INSULATION

Made in one grade only, OKONITE assures a definite dependable measure of quality, —quality that gives service.

OKONITE INSULATED WIRES AND CABLES

VARNISHED CAMBRIC CABLES

OKONITE TAPE

MANSON TAPE

THE OKONITE COMPANY

PASSAIC, NEW JERSEY

AGENTS

Central Electric Company, Chicago, Ill., Gen'l Western Agents
Novelty Electric Co., Philadelphia, Pa.
F. D. Lawrence Electric Co., Cincinnati, O.
Pettingell-Andrews Co., Boston, Mass.

Gage No. B. & S.	Diameter in Mils at 20° C	Pounds per Ohm*		
		0° C (=32° F)	20° C (=68° F)	50° C (=122° F)
0000	460.0	14 180.	13 070.	11 690.
000	409.6	8920.	8219.	7352.
00	364.8	5610.	5169.	4624.
0	324.9	3528.	3251.	2908.
1	289.3	2219.	2044.	1829.
2	257.6	1395.	1286.	1150.
3	229.4	877.6	808.6	723.3
4	204.3	551.9	508.5	454.9
5	181.9	347.1	319.8	286.1
6	162.0	218.3	201.1	179.9
7	144.3	137.3	126.5	113.2
8	128.5	86.34	79.55	71.16
9	114.4	54.30	50.03	44.75
10	101.9	34.15	31.47	28.15
11	90.74	21.48	19.79	17.70
12	80.81	13.51	12.45	11.13
13	71.96	8.495	7.827	7.001
14	64.08	5.342	4.922	4.403
15	57.07	3.360	3.096	2.769
16	50.82	2.113	1.947	1.742
17	45.26	1.329	1.224	1.095
18	40.30	0.8357	0.7700	0.6888
19	35.89	.5256	.4843	.4332
20	31.96	.3306	.3046	.2725
21	28.46	.2079	.1915	.1713
22	25.35	.1307	.1205	.1078
23	22.57	.082 22	.075 76	.067 77
24	20.10	.051 71	.047 65	.042 62
25	17.90	.032 52	.029 97	.026 80
26	15.94	.020 45	.018 85	.016 86
27	14.20	.012 86	011 85	.010 60
28	12.64	.008 090	.007 454	.006 668
29	11.26	.005 088	.004 688	.004 193
30	10.03	.003 200	.002 948	.002 637
31	8.928	.002 012	.001 854	.001 659
32	7.950	.001 266	.001 166	.001 043
33	7.080	.000 7959	.000 7333	.000 6560
34	6.305	.000 5005	.000 4612	.000 4126
35	5.615	.000 3148	.000 2901	.000 2595

* Bureau of Standards.

BARE AND INSULATED WIRES

PHILLIPS WIRE CO.

Pawtucket, R. I.

FINE MAGNET WIRE.

No. B. & S. Gage.	Diameter.	Ohms Per Pound — Single Cotton.	Ohms Per Pound — Double Cotton.	Feet Per Pound — Single Cotton.	Feet Per Pound — Double Cotton.
20	.0319	3.15	3.02	311	298
21	.0284	4.97	4.72	389	370
22	.0253	7.87	7.44	491	461
23	.0225	12.45	11.7	624	584
24	.0201	19.65	18.25	778	745
25	.0179	30.9	28.45	658	903
26	.0159	48.5	44.3	1188	1118
27	.0142	76.5	68.8	1583	1422
28	.0126	120.	106.5	1903	1759
29	.0112	190.5	164.	2461	2207
30	.0100	294.5	252.	2893	2534
31	.0089	461.	384.5	3483	2768
32	.0079	717.	585.	4414	3737
33	.0070	1115.	880.	5688	4697
34	.0063	1715.	1315.	6400	6168
35	.0056	2640.	1960.	8393	6737
36	.005	4070.	2890.	9846	7877
37	.0044	6180.	4280.	11636	9309
38	.0039	9430.	6150.	13848	10666
39	.0035	14200.	8850.	18286	11907
40	.0031	21800.	12500.	24381	14222

WIRES and CABLES

Aerial Cables
Annunciator Wire
Annunciator Cables
Automobile Horn Cord
Automobile Lighting Cables
Automobile Starter Cables
Automobile Charging Cables
Automobile Ignition Cables
Armature Coils
Armature Leads
Asbestos Braided Wire
Brush Cables
Border Light Cables
Brewery Cord
Battery Wire
Bridle Wire
Bare Copper Wire
Bare Copper Strands
Bare Braided Copper
Copper Wire, Bare
Copper Strands, Bare
Charging Cable for Elec. Vehicles
Copper Clad, Rubber Insulated
Cambric Cables
Canvasite Cord
Control Cable for Elevators
Car Wire and Cables
Cotton Tubing or Sleeving
Copper Sleeves
Copper Bells
Compound, Pothead No. 1
Compound, Splicing No. 2
Compound, Telephone No. 3
Drop Wire
Deck Cables
Electric Horn Cord
Electric Vehicle, Charging Cables
Electric Locomotive Cables
Elevator Annunciator Cables
Elevator Lighting Cables
Elevator Control Cables
Enameled Wire
Fixture Wire
Fireproof Wires
Flameproof Wire
Fire and Weatherproof Wire
Field Coils
Friction Tape
Gas Fixture Wire
Gas Engine Cables
Heater Cord
Ignition Cables
Interior Telephone Wire
Insulating Paper
Insulating Tape
Jumper Wire
Lamp Cord
Lighting Cable, Automobile
Locomotive Cables, Mine
Moving Picture Cord
Messenger Strand
Mining Machine Cables
Motor Lead Cable
Magnet Wire
Motor Boat Wires and Cables
Motorcycle Wires and Cables
Office Wire and Cables
Oilproof Finishing Braids
Power Cable, Rubber Insulated
Power Cable, Cambric Insulated
Power Cable, Paper Insulated
Packing House Cord
Paraffine Wax
Rubber Covered Wire, N. E. C. S.
Rubber Tape
Starter Cables
Sweeper Cord
Spider Wire
Stage Cables
Signal Wire and Cables
Submarine Cable
Switchboard Wire
Switchboard Cords
Switchboard Cable
Slow Burning Wire
Solenoids
Secondary Spark Coils
Silk Tubing or Sleeving
Telephone Cords
Telephone Wire
Telephone Cable, Paper Insulation
Telephone Cable, Rub'r Insulation
Tubing, Cotton and Silk
Telegraph Wire
Telegraph Cable, Paper Insulation
Telegraph Cable, Rub'r Insulation
Vacuum Cleaner Cord
Vibrator Cord
Weatherproof Wire

JOHN A. ROEBLING SON'S COMPANY TRENTON, N. J.

New York Boston Chicago Philadelphia Pittsburgh Cleveland
Atlanta San Francisco Los Angeles Seattle Portland, Ore.

TABLE OF IRON, STEEL AND COPPER WIRE.

Gage.	Diameter in .001 inch.			Pounds in One Mile.				Feet in One Pound.				Resistance in Ohms Per Mile.			
	Galvanized Iron B. W. G.	Copper B. S.	Copper Old B. W. G.	Galvanized Iron B. W. G.	Galvanized Steel.	Copper B. & S.	Copper Old B. W. G.	Galvanized Iron B. W. G.	Galvanized Steel.	Copper B. & S.	Copper Old B. W. G.	Galvanized Iron B. W. G.	Galvanized Steel B. W. G.	Copper, B. & S., 60° Fah.	Copper, Old B. W. G., 60° Fah.
1	.300	.289	.300	1251	.....	1328	1438	4.22	.....	4	3.7	3.76	.....	.66	.61
2	.284	.258	.284	1121	.....	1069	1289	4.72	.....	5	4.1	4.19	.....	.81	.68
3	.259	.229	.259	932	.....	835	1072	5.65	.....	6.3	4.9	5.04	.....	1.04	.81
4	.238	.204	.238	787	.....	662	905	6.70	.....	8	5.8	5.97	.....	1.31	.96
5	.220	.182	.220	673	.....	526	774	7.87	.....	10	6.8	6.99	.....	1.65	1.13
6	.203	.162	.203	573	.....	417	659	9.17	.....	12.6	8	8.21	.....	2.08	1.32
7	.180	.144	.180	450	.....	330	518	11.25	.....	16	10.2	10.44	.....	2.63	1.65
8	.165	.129	.165	378	.....	262	435	13.89	.....	20	12.1	12.42	.....	3.32	2.
9	.148	.114	.148	305	.....	208	350	17.25	.....	25	15.1	15.44	.....	4.13	2.49
10	.134	.102	.134	250	.....	165	287	21.29	.....	32	18.4	18.83	.....	5.17	3.04
11	.120	.091	.120	200	.....	131	230	27.03	.....	40	22.9	23.48	.....	6.48	3.79
12	.108	.081	.109	165	163	103	190	32.21	32.4	50	27.8	28.46	39.36	8.2	4.59
13	.095	.072	.095	125	.....	82	144	41.65	.....	64	36.6	37.47	.....	10.39	6.04
14	.083	.064	.083	96	98	65	110	45.51	55.6	81	48	49.08	67.88	13.12	7.91
15	.072	.057	.072	.....	.....	51	83	.....	.....	102	63.7	65.23	.....	16.55	10.5
16	.065	.051	.065	.....	55	41	67	.....	90	126	78.2	80.03	110.70	20.7	12.9
17	.058	.045	.058	.....	.....	32	54	.....	.....	162	98.2	100.50	.....	26.5	16.2
18	.049	.040	.049	.....	.....	26	38	.....	.....	208	137.6	140.80	.....	33.7	22.7
19	.....	.035	.042	.....	.....	20	28	.....	.....	256	187.3	.....	.....	41.5	30.9
20	.....	.032	.035	.....	.....	16	20	.....	.....	323	269.7	.....	.....	52.5	44.5

will build up your sales on

Rubber Covered Code Wire, Lamp Cord, Telephone Wire.

ROUND—SQUARE—FLAT
MAGNET WIRE

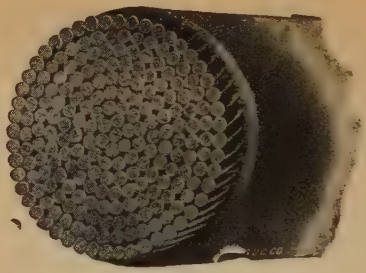
THEY PASS CURRENT EVERYWHERE

Rome Wire Company

ROME, N. Y.

COMPARISON OF WIRE GAGES IN DECIMAL PARTS OF AN INCH.

No. of WireGage	American or Brown & Sharpe	Birmingham or Stubs	Washburn & Moen Mfg. Co., Worcester, Mass.	Trenton Iron Co., Trenton, N. J.	New British	Old English from Brass Mfrs. List
000000	.....	....	.46	....	....	....
00000	.....	....	.43	.45	....	....
0000	.46	.454	.393	.4	.4	....
000	.40964	.425	.362	.36	.372	....
00	.3648	.38	.331	.33	.348	....
0	.32495	.34	.307	.305	.324	....
1	.2893	.3	.283	.285	.3	....
2	.25763	.284	.263	.265	.276	....
3	.22942	.259	.244	.245	.252	....
4	.20431	.238	.225	.225	.232	....
5	.18194	.22	.207	.205	.212	....
6	.16202	.203	.192	.19	.192	....
7	.14428	.18	.177	.175	.176	....
8	.12849	.165	.162	.16	.16	....
9	.11443	.148	.148	.145	.144	....
10	.10189	.134	.135	.13	.128	....
11	.090742	.12	.12	.1175	.116	....
12	.080808	.109	.105	.105	.104	....
13	.071961	.095	.092	.0925	.092	....
14	.064084	.083	.08	.08	.08	.083
15	.057068	.072	.072	.07	.072	.072
16	.05082	.065	.063	.061	.064	.065
17	.045257	.058	.054	.0525	.056	.058
18	.040303	.049	.047	.045	.048	.049
19	.03589	.042	.041	.039	.04	.04
20	.031961	.035	.035	.034	.036	.035
21	.028462	.032	.032	.03	.032	.0315
22	.025347	.028	.028	.27	.028	.0295
23	.022571	.025	.025	.024	.024	.027
24	.0201	.022	.023	.0215	.022	.025
25	.0179	.02	.02	.019	.02	.023
26	.01594	.018	.018	.018	.018	.0205
27	.014195	.016	.017	.017	.0164	.01875
28	.012641	.014	.016	.016	.0148	.0165
29	.011257	.013	.015	.015	.0136	.0155
30	.010025	.012	.014	.014	.0124	.01375
31	.008928	.01	.0135	.013	.0116	.01225
32	.00795	.009	.013	.012	.0108	.01125
33	.00708	.008	.011	.011	.01	.01025
34	.006304	.007	.01	.01	.0092	.0095
35	.005614	.005	.0095	.009	.0084	.009
36	.005	.004	.009	.008	.0076	.0075



STANDARD Products

include a complete line of electric wires, cables and cable accessories of all kinds, sizes and insulations among which are the following:

Copper, Brass and Bronze Wires and Rods
Colonial Copper Clad Steel Wire
Magnet and Weatherproof Wire
Rubber Insulated Wires of all kinds
Lead Covered Light and Power Cables
Lead Covered Telephone Cables
Steel-Wire and Steel-Tape Armored Cables
Cable Terminals and Junction Boxes, etc.

In additon to a large variety of products of superior quality we offer our customers the benefit of 38 years of specialized manufacturing and installation experience.

Write our nearest office for samples and prices.

Standard Underground Cable Co.
Pittsburgh, Pa.

Boston	Washington	Detroit	Seattle
New York	Atlanta	St. Louis	Los Angeles
Philadelphia	Chicago	San Francisco	Salt Lake City

For Canada: Standard Underground Cable Co. of Canada, Limited, Hamilton, Ont.

Metal Conduits. All surfaces of the tube, elbows, bends and similar fittings must be protected against corrosion in an approved manner.

Finished rigid conduit as shipped must be in ten-foot lengths, with each end reamed and threaded. For each length at least one coupling must be furnished. It must have an approved interior coating of a character and appearance which will readily distinguish it from ordinary commercial pipe commonly used for other than electrical purposes.

Outlet, Junction and Flush Switch Boxes. Junction or pull boxes not over 150 cubic inches in size, outlet and flush switch boxes must be of pressed steel not less than 0.078 inch (No. 14, U. S. sheet metal gage), or of cast metal having wall thickness not less than one-eighth inch.

Junction or pull boxes of over 150 cubic inches in size must be of metal and must comply with the detailed specifications for cut-out boxes except that the covers may be single flat sheets secured to the box proper by screws or bolts instead of hinges, if desired. Boxes having covers of this form are for use only for enclosing joints in conductors or to facilitate the drawing in of wires and cables and are not for use in enclosing switches, cut-outs or other forms of control devices.

Boxes must be well galvanized, enameled or otherwise properly coated, inside and out, to prevent oxidation.

It is recommended that the protective coating be of conductive material such as tin or zinc.

Boxes must be so made that all openings not in use will be effectively closed by metal which will afford protection substantially equivalent to the walls of the box.

Fittings including conduit box covers designed for bringing conductors, other than flexible cords or pendants, from metal conduit to exposed wiring must be provided with non-absorptive, non-combustible insulating bushings, which, except with flexible cord, must separately insulate each conductor . For flexible cords or for pendants such fittings including covers of outlet boxes must be provided with approved bushings or must have smooth, well-rounded surfaces on which the cords shall bear.

Boxes must, in case of combination gas and electric outlets, be so arranged that connection with gas pipe at outlet may be made by means of an approved device.

Fixture studs where not a part of the box must be made of malleable iron or other **approved** material.

Conduit or flexible tubing entering the boxes must be firmly secured in position by means of some **approved** device which may or may not be a part of the box.

Switch and outlet boxes must be so arranged that they can be securely fastened in place independently of the support afforded by the conduit piping, except that when entirely exposed, **approved** boxes, which are threaded so as to be firmly supported by screwing on to the conduit, may be used.

Switch and receptacle boxes must completely enclose the switch or receptacle on sides and back, and must provide a thoroughly substantial support for it. The retaining screws for the box must not be used to secure the switch in position. Boxes for floor outlets shall be designed to completely enclose the receptacle and attachment plugs, if any, to protect them from mechanical injury and to exclude moisture.

Covers for outlet boxes if made of metal must be equal in thickness to that specified for the walls of the box, or must be of metal lined with an insulating material not less than one-thirty-second inch in thickness, firmly and permanently secured to the metal. Covers may also be made of porcelain or other approved material, provided they are of such form and thickness as to afford suitable protection and strength.

Raceways for Surface Wiring

Wooden Raceways. These must have, both outside and inside, at least two coats of waterproof material, or be impregnated with a moisture repellent.

They must be made in two pieces, a backing and a capping, and must afford suitable protection from abrasion. They must be so constructed as to thoroughly encase the wire, be provided with a tongue not less than one-half inch in thickness between the conductors, and have exterior walls which under grooves shall be not less than three-eights inch in thickness, and on the side not less than one-fourth inch in thickness.

It is suggested that only hardwood be used.

Metal Raceways. These must be constructed in a manner to distinguish them from metal conduit.

All surfaces of the raceways, elbows, bends and similar fittings must be protected against corrosion in an approved manner.

The raceways and all elbows, couplings and similar fittings must be so made and installed as to secure the

sections together both mechanically and electrically and protect the conductors from abrasion. Holes for screws or bolts inside the raceway must be arranged so that when screws or bolts are in place the heads will be flush with the metal surface.

Cleats, Knobs, Tubes and Bushings. These must be made of approved non-combustible, non-absorptive insulating material, free from checks, rough projections or sharp edges which might injure the insulation of the wire.

For wires larger than No. 4 B. & S. gage split knobs (single wire cleats) must have provision for two supporting screws.

Spacings. At least one-fourth inch separation must be maintained between the supporting screw or nail and the conductor.

Cleats must conform to the specifications given in the following table:

Voltage	Distance from Wire to Surface	Distance between Wires.
0-300	½-inch	2½ inches

Knobs must be so constructed as to separate the wire at least one inch from the surface wired over.

Knobs must be constructed to conform to the following minimum dimensions:

Size of Wire Inclusive	Size of Base, Inches. Circular Knobs, Diameter	Square Knobs or Single Wire Cleats. Width	Square Knobs or Single Wire Cleats. Length	Solid Knobs, Groove, Inches. Depth	Solid Knobs, Groove, Inches. Diameter	Split Knobs, Thickness of Cap, Inches from Top of Wire Groove.
14-10	1⅛	¾	1¾	7/32	¼	3/8
8-4	1½	⅞	2	7/32	¼	3/8
2-00	2	1	2¼	7/32	5/8	5/8
000-300,000 C. M.	2½	1⅓	2¾	9/32	23/32	⅞
400,000-1,000,000 C. M.	3	1⅔	3¾	5/8	1¼	1

The Cook Wedge Split Insulator

Two GROOVE for 10, 12, 14 Wire

Makes Standard Wiring Easy

Made of the Best Hard White Porcelain. No Burrs or Rough Edges to Cut Insulation, but Firmly Grips the Wire when Screwed in Place. The Cap Needs No Centering. Once Used Never Replaced.

Trial Orders Packed 500 in a Box

Now Furnished Complete with Nail and Leather Nail Head

Note that the Nail is not Weakened by Crimping

Protected by U. S. Patents

Ask Your Jobber or Write Us for Samples and Prices

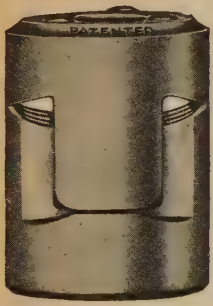
COOK POTTERY CO.

Trenton, N. J.

SOLE MANUFACTURERS

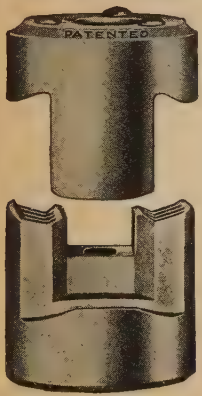
"BUCKEYE" the new split knob

Lessens Breakage Expense Saves Time and Labor—



The Buckeye Knob is interchangeable, every piece being exactly alike. Counting of pieces and matching tops and bottoms eliminated. It is interlocking and cannot twist nor get out of alignment, either while being installed or afterward—this saves the wireman's time and makes the work easier.

Every piece being exactly alike, the breaking of one does not destroy or make useless a whole knob.



Pat. June 20, 1911
No. 995838

The wire grooves are deep and hold the wire firmly without injuring insulation.

The Buckeye may be installed with either screw or nail.

The Buckeye is the only Interlocking Reversible Knob having two wire grooves on the same plane.

Made in two sizes—Strong, light and very neat appearing.

Write for prices and catalog of our full line standard and special porcelain.

Findlay Electric Porcelain Co.

FINDLAY, OHIO

Flexible Tubing. The tubing must have a smooth interior, and its outer surface must be treated with a moisture repellent and must not convey fire when ignited and held in a vertical position. The tubing must be so designed that the interior lining, if any, is not removable in lengths of over three (3) feet and be sufficiently tough and tenacious to withstand any abrasion likely to be met with in practice.

Switches. A knife switch is a switch having electrical connecting parts in the form of hinged or pivoted bars or blades and designed for manual operation.

Under this term are included single or multiple pole switches, either with or without fuse terminals, switches having individual bases designed for either front or rear wiring connections: also switch parts without separate bases intended for mounting on switchboards and panelboards.

Classification and Marking. Must be plainly marked where it can be read when the switch is installed, with the current and the voltage for which the switch is designed, as follows:

For switches of capacities above 1,000 amperes, the A. C. rating will generally be less than the D. C. rating, and in such cases the marking should indicate the ampere rating definitely as A. C. or D. C. The frequency in cycles should also be stated.

Classification	Markings
30 to 1,000 amperes inclusive	
125 V., D. C. or A. C. Only for switchboards and panelboards. (With or without fuses.)	125 V., ... Amps.
250 V., D. C. or 500 V., A. C. (Without fuses.)	250 V., D. C., 500 V., ... A. C. Amps.
250 V., D. C. or A. C. (With fuses.)	250 V.....Amps.
500 V., A. C. (With 600 volt fuses.)	500 V., A. C. ... Amps.
600 V., D. C. or A. C. (With or without fuses.)	600 V., ... Amps.
Triple-pole: With 125 volt spacings between blades. For use on three-wire systems having 125 volts between adjacent wires and not over 250 volts between outside wires.	125 V., ... Amps.

Triple-pole: With 250 volt spacings between blades. For use on three-wire systems having 250 volts between adjacent wires and not over 500 volts between outside wires. — 250 V., ... Amps.

Mounting. Pieces carrying, or used to hold the break and hinge jaws, must be secured to the base or mounting surface in such a manner as to prevent possible turning.

The cross bar must be secured to each blade in such a manner as to prevent turning and twisting.

Spacings. The spacings given below are standard and are to be considered as the minimum allowable, except as otherwise provided for.

The measurements given under Tables 1 and 2 are to be taken within the area of the switch base bounded by the contact parts of the switch mechanism (break and hinge jaws). The measurements outside of the zone of the switch mechanism shall not be less than given under Table 3.

The dimensions given for break distances do not apply to quick break attachments on switch mechanisms.

TABLE 1

For Switchboards and Panels Only

Ampere Rating	125 V., D. C. or A. C. Opposite Polarity	Break Distance
30	1	¾
60	1¼	1

TABLE 2

For All Other Switches

Ampere Rating	125 V., D. C. or A. C. Opp. Pol.	Break	250 V., D. C. or A. C. Opp. Pol.	Break
30	1¼	1	1¾	1½
60	1½	1¼	2¼	2
100	1½	1¼	2¼	2
200 and 300	2¼	2	2½	2¼
400 and 600	2¾	2½	2¾	2½
800 to 6000 incl.	3	2¾	3	2¾

TABLE 2 (Continued)

	250 V., D. C. or 500 V., A.C.		600 V., D. C. or A. C.	
	Opp. Pol.	Break	Opp. Pol.	Break
30	1½	1½	4	3½
60	2¼	2	4	3
100	2¼	2	4½	4
200 and 300				
400 and 600				
800 to 6000 incl.				

Three hundred ampere switches are to be used only on switchboards.

TABLE 3

Spacings between Parts of Opposite Polarity outside the area bounded by the contact parts of the switch mechanism (except for Link Fuses).

Switches above 1,000 amperes capacity should not be used to break currents, but only as disconnecting switches.

	When Mounted on Same Surface	When Clear of Surface
Not over 125 V	¾ inch	½ inch
Not over 250 V	1¼ inch	¾ inch
Not over 600 V	2 inch	1¾ inch

Fuse Terminals. Switches rated above 400 amperes at 600 volts and 600 amperes at 250 volts, and therefore exceeding the capacities of standard sizes of cartridge enclosed fuses, may be arranged for fuses in multiple, provided as few fuses as possible are used, that the fuses are of equal capacity, and that the multiple terminals for each pole are mounted in common.

Switches marked with the combined rating, 250 volts, D. C., or 500 volts, A. C., must not be provided with fuse terminals.

Switches having fuse terminals and intended for use in the ultimate or branch circuits, in direct connection with lamps or other translating devices, must have fuse terminals in each pole.

Auxiliary Contacts. Auxiliary contacts of a renewable or quick-break type or the equivalent are recommended for D. C. switches rated at over 250 volts and must be provided on all 600-volt switches designed for use in breaking currents from 200 to 1,000 amperes, inclusive.

Barriers. Barriers designed to be placed between the poles and switches and not located within the influence of the arc must be of non-absorptive insulating material. Barriers placed between the poles of switches and located within the influence of the arc formed by the opening of the switch must be of non-combustible, non-absorptive, insulating material.

Barriers, designed to be placed between poles of switches as hinge jaws must be of such a size and so located as to provide a separation between contact parts measured in the shortest insulating surface path over the barrier equal to that required for switches without barriers, and to provide a separation between other current carrying parts, as given under "Spacing."

Barriers placed between the poles of switches at the break jaws and, therefore, located within the influence of the arc formed by the opening of the switch, must be of such size and so located as to provide a separation between contact parts measured in the shortest path through air over the barrier equal to that required for switches without barriers.

Multiple Pole Switches. Switches designed for double throw and having three or more poles, must not have front-connected terminals for the hinge contacts of the inner poles, unless standard switch spacings between adjacent live metal parts of opposite polarity are secured either by increased spacing between poles or by the use of barriers.

Circuit Breakers. Automatic overload circuit breakers must be substantial in construction, and must have ample metal for stiffness. The contact parts shall be arranged so that thoroughly good bearings are obtained. All breakers must be provided with easily accessible means of tripping them by hand without injury to the operator.

Link Fuse Cut-Out Bases

Spacings. Spacings must be at least as great as those given in the following table, which applies only to plain, open fuse blocks, mounted on slate or marble bases. If the copper fuse-tips overhang the edges of the fuse block terminals, the spacings should be measured between the nearest edges of the tips.

A space must be maintained between fuse terminals of the **same polarity** of at least one-half inch for voltages up to 125, and of at least three-quarter inch for voltages from 126 to 250. This is the minimum distance allowable, and greater separation should be provided when **practicable.**

For three wire systems cut-outs must have the break-distance required for circuits of the potential of the outside wires, except that in 125-250-volt systems with grounded neutral the cut-outs in two-wire, 125-volt branch circuits may have the spacings specified for not over 125 volts.

Ampere Capacity.	Minimum Separation of Nearest Metal Parts Opposite Polarity.	Minimum Break Distance.
Not over 125 volts.		
0- 10	¾ inch	¾ inch
11- 100	1 "	¾ "
101- 300	1 "	1 "
301-1000	1¼ "	1¼ "
Not over 250 volts.		
0- 10	1½ inch	1¼ inch
11- 100	1¾ "	1¼ "
101- 300	2 "	1½ "
301-1000	2½ "	2 "

Enclosed Fuse Cut-Out Bases—Plug and Cartridge Type

Fuse Terminals. Except for sealable service and meter cut-outs fuse terminals must be of either the Edison plug, spring clip or knife blade type, to take the corresponding standard enclosed fuses. They must be secured to the base by two screws or the equivalent, so as to prevent them from turning, and must be so made as to secure a thoroughly good contact with the fuse. End stops must be provided to insure the proper location of the cartridge fuse in the cut-out base.

Classification. Bases must be classified as regards both current and voltage as given in the following table, and must be so designed that the bases of one class cannot be used with fuses of another class rated for a higher current or voltage.

STANDARD PLUG OR CARTRIDGE CUT-OUTS

Not Over 250 Volts	Not Over 600 Volts
0- 30 amperes	0- 30 amperes
31- 60 "	31- 60 "
61-100 "	61-100 "
101-200 "	101-200 "
201-400 "	201-400 "
401-600 "	

Not Over 250 Volts	Not Over 600 Volts
0- 30 amperes	0- 30 amperes
31- 60 "	31- 60 "
61-100 "	61-100 "
101-200 "	101-200 "

Link Fuses

Contact Tips. Contact surfaces or tips must be of copper or aluminum, having perfect electrical connections with the fusible part of the strip.

Rating. Link fuses must be stamped with 80 per cent. of the maximum current which they can carry indefinitely, thus allowing about 25 per cent. overload before the fuse melts.

Construction. The fuse casing must be sufficiently tight so that lint and dust cannot collect around the fusible link and become ignited when the fuse is blown.

The fusible wire must be attached to the terminals in such a way as to secure a thoroughly good connection and to make it difficult for it to be replaced when melted.

Classification. Fuses must be classified to correspond with the different classes of cut-outs, and must be so designed that it will be impossible to put any fuse of a given class into a cut which is designed for a current or voltage lower than that of the class to which the fuse belongs.

Marking. Fuses must be marked with the words "N. E. Code Std."

The tube or ferrules of ferrule contact fuses and the tubes or caps of knife-blade fuses shall be marked with the labeled capacity.

In addition to the above marking each fuse must be provided with a paper label—green for 250 volt fuses and red for 600 volt fuses.

The label must bear the following: the name or trade-mark of the manufacturer and the voltage for which the fuse is designed.

Terminals. The fuse terminals must be sufficiently heavy to insure mechanical strength and rigidity. The

styles of terminals, except for use in sealable service and meter cut-outs, must be as follows:

Not over 250 volts.

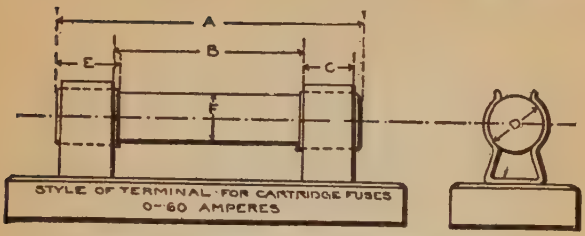
0- 30 Amps.	A. Cartridge fuse (ferrule contact). B. Approved plug or cartridge fuses in approved casings for Edison plug cut-outs not exceeding 125 volts, but including any circuit of a three-wire 125-250-volt system with grounded neutral.
31- 60 "	Cartridge fuse (ferrule contact) for use also in approved casings for large size Edison plug type 250-volt cut-outs.
61-100 " 101-200 " 201-400 " 401-600 "	Cartridge fuse (knife-blade contact).

Not over 600 volts.

0- 30 Amps. 31- 60 "	Cartridge fuse (ferrule contact).
61-100 " 101-200 " 201-400 "	Cartridge fuse (knife-blade contact).

Dimensions. Cartridge enclosed fuses and corresponding cut-out bases, except for sealable service and meter cut-outs, must conform to the dimensions given in the table on the following pages.

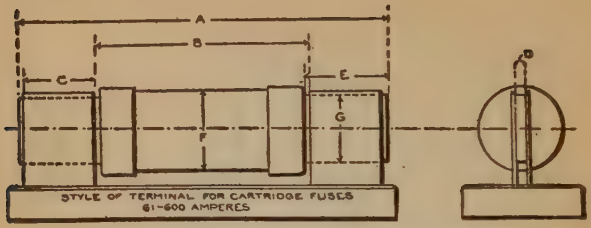
Table of Dimensions of the Standard Cartridge



Form 1. CARTRIDGE FUSE—Ferrule Contact.

Voltage	Rated Capacity. Amperes.	A Length over Terminals. Inches.	B Distance between Contact Clips. Inches.	C Width of Contact Clips. Inches
0-250.	0-30	Form 1 2	1	$\frac{1}{2}$
	31-60	Form 1 3	$1\frac{3}{4}$	$\frac{5}{8}$
	61-100	Form 2 $5\frac{7}{8}$	4	$\frac{7}{8}$
	101-200	Form 2 $7\frac{7}{8}$	$4\frac{1}{2}$	$1\frac{1}{4}$
	201-400	Form 2 $8\frac{5}{8}$	5	$1\frac{3}{4}$
	401-600	Form 2 $10\frac{5}{8}$	6	$2\frac{1}{8}$
251-600	0-30	Form 1 5	4	$\frac{1}{2}$
	31-60	Form 1 $5\frac{1}{2}$	$4\frac{1}{2}$	$\frac{5}{8}$
	61-100	Form 2 $7\frac{7}{8}$	6	$\frac{7}{8}$
	101-200	Form 2 $9\frac{5}{8}$	7	$1\frac{1}{4}$
	201-400	Form 2 $11\frac{5}{8}$	8	$1\frac{3}{4}$

National Electrical Code
Enclosed Fuse.



Form 2. CARTRIDGE FUSE—Knife Blade Contact.

D	E	F	G	
Dia. of Ferrules or Thickness of Terminal Blades. Inches.	Min. Length of Ferrules or of Terminal Blades Outside of Tube. Inches.	Dia. of Tube. Inches.	Width of Terminal Blades. Inches.	Rated Capacity. Amperes
9/16 13/16	1/2 5/8	1/2 3/4	Form 1	0-30 31-60
1/8 1 1/16 1/2 1/2	1 1 5/8 1 1/8 2 1/2	1 1 1/4 2 2 1/2	3/4 1 1/8 1 5/8 2 Form 2	61-100 101-200 201-400 401-600
13/16 1 1/16	1/2 5/8	3/4 1	Form 1	0-30 31-60
1/8 9/16 1/2	1 1 5/8 1 7/8	1 1/2 1 3/4 2 1/2	3/4 1 1/8 1 5/8 Form 2	61-100 101-200 201-400

TRICO

REG. U. S. PAT. OFF.

STANDS FOR FUSE PERFECTION

Trico is the only approved, in all capacities, renewable fuse, using the advantageous POWDER FILLED renewal element.

Fully Approved
All Sizes and Voltages

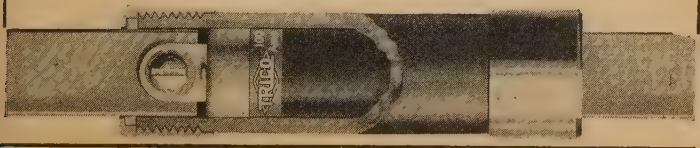
Trico Renewable Cartridge Fuses are approved by the Underwriters Laboratories in all standard sizes, including the 250 and 600 volt classification from 0 to 600 Ampere. The UND. LAB. inspected label is attached to all Trico Fuses and is your protection against inferior product.

The Underwriters Laboratories have this to say about Trico Renewal Elements:

"The inner or renewal cartridge provides a link of a form not easily duplicated by the user or likely to be replaced by improper substitutes. The combination of a **powder filler** surrounding the link closely approximates the essential features of design of standard enclosed fuses of the non-renewable type."

Let this be your guide to better and cheaper fuse protection.

THE M. B. AUSTIN CO.
CHICAGO



The one reliable make of fuses that embodies every element of accuracy, quality and mechanical perfection to give full protection from all electrical hazards.

BUSS PRODUCTION

1915—291,767

1916—1,325,538

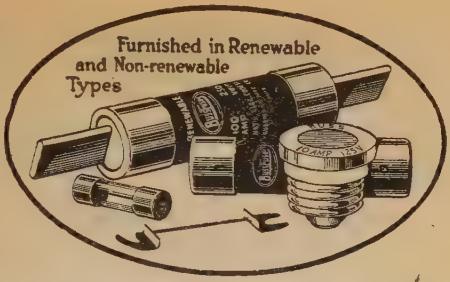
1917—4,650,297

1918—9,082,241

1919—OVER 16,000,000

Made in all types for all purposes

Sold by dealers everywhere



BUSS

Renewable FUSES

In All Sizes (3 to 600 Amp.)
and Both Voltages (250 and 600 V.)

Are Approved by
Underwriters Laboratories
(Incorporated)
and labeled
"UNDERWRITERS' LABORATORIES
INSPECTED"

The Buss Renewable Fuse makes the use of renewable fuses a real economy. Write for a demonstration.

BUSSMANN MFG. CO., St. Louis

Branch Stocks Carried at

NEW YORK, 731 Broadway
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SAN FRANCISCO, 509 Mission St.

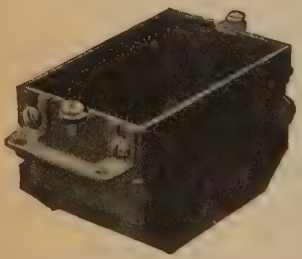
"UNION"

N. E. C. FUSES
N. E. C. CUT-OUTS
N. E. C. OUTLET BOXES
N. E. C. SWITCH BOXES

No. 1021

No. 2004

No. 105 C Cover



"Gem" F Switch Box

No. 106 O Box

All are standard goods—well and favorably known to the Electrical Trade.

They are backed by 30 years of manufacturing experience.

Carried by Electrical Supply Dealers Everywhere.

Write for Latest Catalog.

Chicago Fuse Mfg. Co.

Chicago **New York**

"UNION"

Renewable and Non-Renewable

FUSES

N. E. C. STANDARD

Would you send the same truck for an express package as for a load of coal?

Why not fuse your electrical circuits with the same degree of judgment?

The "Union Way"

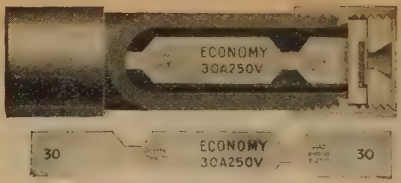
of fusing is the logical way—use "UNION" Renewable Fuses with low cost refills on circuits that are frequently overloaded, and "UNION" Non-Renewable Fuses with low first cost on circuits rarely overloaded.

This will give you maximum protection at minimum cost. "UNION" Fuses are backed by over thirty years' manufacturing experience.

Sold by Dealers in Electrical Supplies.

Chicago Fuse Mfg. Co.

Chicago **New York**



Ferrule Type Fuse

ECONOMY FUSE & MFG. CO.

CHICAGO ILLINOIS

Branch Offices in All Principal Cities

Complete Stocks Carried by All Leading Jobbers and Dealers

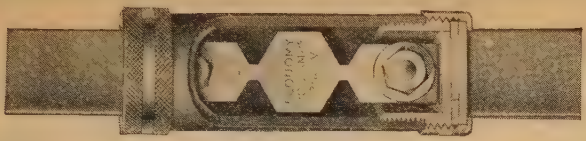
PRODUCTS:

Economy Approved Renewable Cartridge Fuses
"Arkless" Non-Renewable Indicating Fuses

ECONOMY "APPROVED IN ALL CAPACITIES" FUSES

Economy fuses are made in two general types (ferrule and knife blade) with a full line of capacities for all commercial voltages. They are approved — IN ALL CAPACITIES — by the UNDERWRITERS' LABORATORIES, established and maintained by the NATIONAL BOARD OF FIRE UNDERWRITERS.

AN INEXPENSIVE ECONOMY "DROP OUT" RENEWAL link almost instantly restores a blown fuse to its original efficiency. The Economy renewal link feature consists of two narrow bridges of metal which hold the "Drop Out" section in place. In operation on short circuits these two bridges fuse. The entire fuse metal does not volatilize—only the two narrow bridges—thus decreasing the danger factor due to the tremendous pressure generated when an entire strip of fusible metal is instantly converted into gases. No powdered filler to deteriorate or solidify. Only the fuse metal is destroyed.

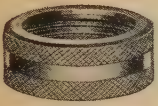


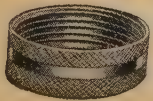
Knife Blade Type

ECONOMY RENEWABLE FUSES ARE APPROVED IN ALL CAPACITIES

ECONOMY renewable FUSES cut annual fuse maintenance costs 80% as compared to the use of one-time fuses.

The use of Economy Fuses in establishments where the fire hazard is great (powder factories, arms and munition plants, chemical works, flour mills, submarines, battle ships, etc.), and where "safety first" is the highest consideration, is proof of their safety in use.





THE IMPROVED ECONOMY RENEWABLE FUSE:

The winged washer makes it simple and easy for anyone to replace the Economy "Drop Out" Renewal Link in a few minutes. Unlock the winged washer, replace the blown link, reassemble the parts and press home the wings of the washer, securely locking the renewed fuse.

Sold by All Leading Dealers and Jobbers

Write for Catalogue and Price List No. 103

ECONOMY FUSE & MFG. CO.

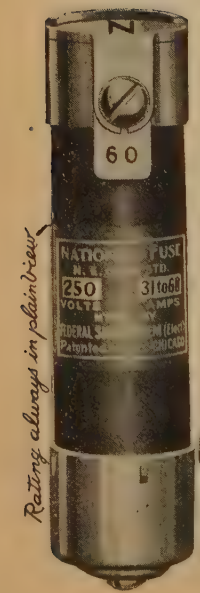
CHICAGO, U. S. A.

The NATIONAL is APP

The National Renewable fuse is approved by the Underwriters' Laboratories, Incorporated, their report E-4199 December 1, 1919.

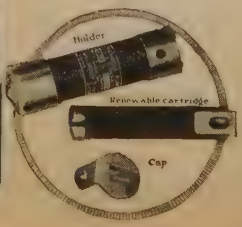
It is the only renewable fuse that is approved by the Associated Factory Mutual Fire Insurance Companies.

It is also approved by the Millers' Mutual Fire Insurance Companies.



Rating always in plain view

Simplicity— Only 3 Parts— Easy to Reload



Renewable FUSE
ROVED

Only one element of the proper size and rating can be used at a time in the National Renewable Fuse.

The Powder packed element confines and smothers the fierce heat of the arc when the fuse blows and also protects and increases the life of the outer casing or holder. The indestructible metallic tell-tale indicator enables you to tell the amperage rating at a glance.

There are only 3 parts to the ferrule type fuse and only 5 parts to the knife blade type fuse. It can be reloaded in a jiffy.

If you have not received a copy of "CORRECT FUSE RATINGS FOR MOTOR CIRCUITS," request same when writing for information and prices.

FEDERAL ELECTRIC COMPANY

Lake and Desplaines Sts., CHICAGO

627 W. 43d St.
NEW YORK CITY

91 New Montgomery St.
SAN FRANCISCO

Branches in all large cities.

Panelboards

The following specifications are intended to apply to all panel and distributing boards used for the control of light and power circuits, but not to such switchboards in central stations, sub-stations or isolated plants as directly control energy derived from generators or transforming devices.

Design. The specifications for construction of switches and cut-outs must be followed as far as they apply.

In the relative arrangement of fuses and switches, the fuses may be placed between the bus-bars and the switches, or between the switches and the circuits. When the branch switches are between the fuses and bus-bars, the connections must be so arranged that the blades will be dead when the switches are open.

When there are exposed live metal parts on the back of board, a space of at least one-half inch must be provided between such live metal parts and the cabinet in which the board is mounted.

Spacings. The following minimum distance between bare live metal parts (bus-bars, etc.) must be maintained:

Between parts of opposite polarity except at switches and link fuses.	Between parts of same polarity.	
When mounted on the same surface	When held free in air.	At link fuses.
Not over 125 volts, ¾ inch	½ inch	½ inch
Not over 250 volts, 1¼ inch	¾ inch	¾ inch
Not over 600 volts, 2 inch	1¾ inch	

At switches or enclosed fuses, parts of the same polarity may be placed as close together as convenience in handling will allow.

It should be noted that the above distances are the minimum allowable, and it is urged that greater distances be adopted wherever the conditions will permit.

The spacings given in the first column apply to the branch conductors where enclosed fuses are used.

The spacings given in the second column apply to the distance between the raised main bars and between these bars and the branch bars over which they pass.

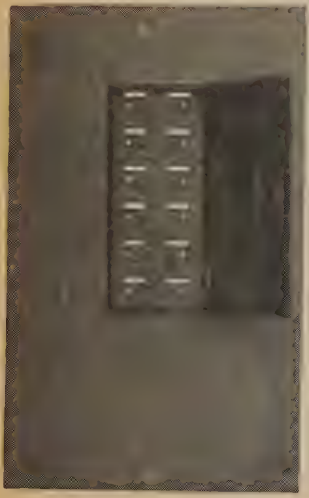
The spacings given in the third column are intended to prevent the melting of a link fuse by the blowing of an adjacent fuse of the same polarity.

Cabinets and Cut-Out Boxes. Cabinets are designed either for surface or for flush mounting and are provided with frames, matts or trims, etc., in which swinging doors are hung.

SAFETY Panels FA Cabinets

TYPE - PPS

A Standard Panel and Cabinet
that is
Universally Popular



With Front.

With Front Removed.

—and equipped with FA Adjustable Corner Supports.

Write for Descriptive Catalogue.

FRANK ADAM ELECTRIC COMPANY

St. Louis, Mo.

Manufacturers of

Switchboards
Knife Switches
Major Theatre Switchboards

FA

Panels
Hanger Outlets
Safety First Material

Cut-out boxes are designed for surface mounting and have swinging doors or covers secured directly to and telescoping with the walls of the box proper.

Cabinets or cut-out boxes intended for installation out-of-doors must be of weatherproof type.

Cabinets and cut-out boxes, when used to enclose devices or apparatus connected within the cabinet or cut-out box to the wires of more than four circuits, not including the supply circuit or a continuation thereof, must have back wiring spaces or one or more side wiring spaces, side gutters or wiring compartments unless the wires leave the cabinet or cut-out box directly opposite their terminal connections.

Design and construction of all cabinets and cut-out boxes must be such as to insure ample strength and rigidity.

The spacing within cabinets and cut-out boxes must be sufficient to provide ample room for the distribution of wires and cables placed in them, and for a separation between metal parts of cabinets or cut-out boxes and current carrying parts of devices and apparatus mounted within them as follows:

1. There must be an air space of at least 1/16-inch, except at points of support, between the base of the device and the wall of any metal cabinet or cut-out box on which the device is mounted.

2. There must be an air space of at least one inch between any enclosed fuse or current carrying part and the door unless the door is lined with an approved insulating material or is of a thickness at least that of No. 12 U. S. gage when the air space must be not less than one-half inch.

3. There must be a space of at least two inches between open link fuses and metal lined walls or metal, metal lined or glass paneled doors.

4. Except as noted above there must be an air space of at least one-half inch between the walls, back, gutter partition, if of metal, or door of any cabinet or cut-out box and the nearest exposed current-carrying part of devices mounted within the cabinet where the potentials do not exceed 250 volts. This spacing must be increased to at least one inch where the potentials exceed 250 volts.

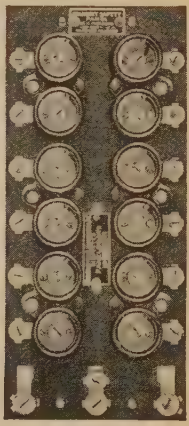
5. Cabinets and cut-out boxes must be deep enough to allow the doors to be closed when 30-ampere branch circuit panelboard switches having spool or composition handles or when switches of combination cut-outs are in any position, and when other single throw

BENJAMIN - STARRETT PANEL BOARDS

Benjamin-Starrett Panel Boards are made in Standard Unit Panels of 4, 6, 8 and 10 circuits which may be combined and built up to any desired capacity *Dead Front* Panel Boards.

Standard Unit Stock Panels (not dead front) come to the Contractor completely assembled and ready for installation.

Standard Dead Front Panel Board in Cabinet



Standard Unit Panel in Jobbers' Stock

Note these brief specifications:

Bases—strong fireproof composition

Bus bars—hard drawn copper, concealed in base

Branches—Edison plug fuse receptacles

Finish—bases dead black, terminals bright copper, lacquered

National Electrical Code Standard

Send for Complete Panel Board Catalog

BENJAMIN ELECTRIC MFG. CO.

New York **Chicago** **San Francisco**

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BENJAMIN PRODUCTS

switches are thrown open as far as their construction and installation will permit.

6. Cabinets having one or more side wiring spaces, side gutters or side wiring compartments must be furnished with covers, barriers or partitions extending around or from the side or sides of all bases or groups of bases of the switches, cut-outs, circuit breakers or feeder and circuit branch panelboards within the cabinet and providing a close fit with the door, frame or sides of the cabinet so as to enclose these spaces, gutters or compartments and the wires stowed within them. At sides where wires or cables are led from the cabinet at points directly opposite their terminal connections to devices or apparatus within the cabinet, and other wires or cables are not placed, these covers, barriers or partitions may be omitted.

When cabinets have back wiring spaces which are not entirely enclosed, covers must be furnished to provide equivalent enclosure.

Cabinets made of wood or composition material, whether for flush or surface mounting, must be rigid and substantial. Doors must fit closely. The detailed specifications for sheet metal cabinets must be followed so far as they apply.

Wood, when used for the construction of cabinets must be well seasoned, at least three-fourths inch in thickness, and shall be thoroughly filled and painted. Cabinets made of wood must be completely lined with a non-combustible material firmly secured in place. Linings of slate, marble or approved composition must be at least one-quarter inch in thickness. Sheet metal, if used as lining, must be at laest No. 16 U. S. sheet metal gage. One-eighth inch rigid asbestos board may be used for linings when firmly secured in place.

Cabinets built of composition material must be made up as is specified for wooden cabinets and must be submitted for special approval before being used.

Inside dimensions of wooden and composition cabinets must provide the spacings called for. Barriers for gutters and wiring compartments must be provided when and as specified.

Rosettes

Bases. Bases for the knob and cleat type must have at least two holes for supporting screws; must be high enough to keep the wires and terminals at least one-half inch from the surface to which the rosette is attached, and must have a porcelain lug under each terminal to prevent the rosette from being placed over

projections which would reduce the separation to less than one-half inch.

Bases for the raceway and conduit box types must be high enough to keep the wires and terminals at least three-eighths inch from the surface wired over.

Rating. Fuseless rosettes may be rated three amperes, 250 volts; fused rosettes with link fuses, not over two amperes, 125 volts.

Fuses. Fused rosettes must have a fuse in each pole.

Sockets and Lamp Receptacles

Classification. Lamp holding devices shall be classed according to diameters of lamp bases, as Candelabra, Medium and Mogul Base, to be known respectively as ½-inch, 1 inch and 1½ inch nominal sizes, with ratings as specified in the following table:

		Ratings.					
		Key.			Keyless.		
Class.	Nominal Diam.	Watts.	Volts.	Max. amp. at any voltage.	Watts.	Volts.	Max. amp. at any voltage.
Candelabra	½"	75	125	¾	75	125	1
Medium	1 "	250	250	2½	660	250	6
	(a)	660	250	6	660	600	
Mogul	1½"				1500	250	
	(b)				1500	600	

(a) This rating may be given only to sockets having a switch mechanism which produces both a quick "make" and a quick "break" action.

(b) Ratings to be assigned later, pending further discussion with manufacturers.

Miniature sockets and receptacles having screw shells smaller than the candelabra size may be used for Decorative Lighting Systems, Christmas Tree Lighting outfits, and similar purposes.

Lining. The inside of metal shells must be lined with insulating material, which must absolutely prevent the shell from becoming a part of the circuit, even though the wires inside the sockets should become loosened or detached from their position under the terminal screws.

The lining must not extend beyond the metal shell more than one-eighth of an inch, but must prevent any current carrying part of the lamp base from being exposed when a lamp is in the socket.

The cap must also be lined.

In sockets and receptacles of standard forms a ring of any material inserted between an outer metal shell

Catalog No. 92
Two-Way Plug

Catalog No. 903
Swivel Attachment Plug

Catalog No. 4207
"Benco" Weatherproof Pull Chain Socket

BENJAMIN TWO-WAY PLUG

Double the outlets—without extra wiring. Convenient for attaching electrical appliances.

If shade is desired, use shade holder shown.

The Swivel Attachment Plug Screws into the socket without twisting the cord and should be used on all portable appliances.

The other devices pictured are but a few of the many Benjamin wiring devices making for convenience and safety.

Benjamin Products Include

ELECTRIC LIGHTING SPECIALTIES
INDUSTRIAL LIGHTING EQUIPMENT
WIRING DEVICES
MARINE LIGHTING AND SIGNALING APPARATUS
INDUSTRIAL SIGNALS
PANEL BOARDS AND CABINETS
PUNCH PRESS EFFICIENCY AND SAFETY DEVICES
ENAMELED STEEL REFLECTORS SPECIALTIES
STAMPING AND DRAWN WORK

Catalog No. 2452
Shade Holder

Catalog No. 7665
Safety Flush Receptacle

Catalog No. 836
Benjamin Stand Lamp Cluster

Write for illustrated catalog and get more facts

BENJAMIN ELECTRIC MFG. CO.

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BENJAMIN PRODUCTS

EVERY DEVICE NEEDED BY THE WIREMAN AND THE ELECTRICAL CONTRACTOR

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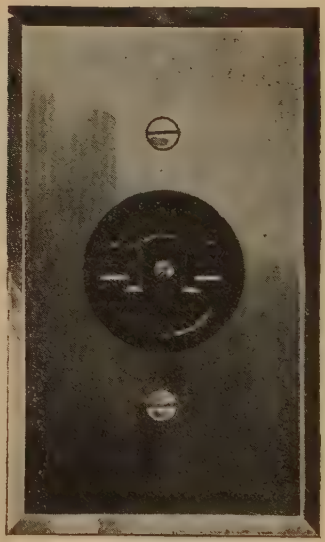
THE BRYANT ELECTRIC CO.

BRIDGEPORT, CONN.

NEW YORK SAN FRANCISCO CHICAGO

HUBBELL
Standard
Interchangeable
Plugs and Receptacles



Hubbell Plug Caps Fit All Hubbell Standard Recep-tacle Bases

A line of high grade wiring devices which has been received with marked favor by the Electrical Trade—so much so, that they have come to be recognized as STANDARD.

HARVEY HUBBELL, Inc.
BRIDGEPORT, CONN.

Levolier

A Double Duty Pull Socket with a Capacity of

660 watts—250 volts

Costs Less—Lasts Longer
Simply Constructed
Mechanically Perfect

Mc Gill Mfg. Co.

No. 2 Beach St.

VALPARAISO -- INDIANA

of the device and the inner screw shell for insulating purposes and separable from the device as a whole, is considered an undesirable form of construction. This does not apply to the use of rings in lamp clusters or in devices where the outer shell is of porcelain, where such rings serve to hold the several porcelain parts together, and are thus a necessary part of the whole structure of the device.

Assembly. The socket as a whole must be so put together that parts will not rattle loose or fall apart under the most severe conditions they are likely to meet with in practice. The base of the socket must be secured or held in the shell in such a manner as to prevent turning or displacement relative to the shell.

Lead Wires (Leading-in-Wires). Lead wires furnished as a part of sockets and intended to be exposed after installation must be of **approved** stranded, rubber covered wire, not less than No. 14 B. & S. gage (No. 18 B. & S. gage for candelabra sockets), and be sealed in place.

Insulating Joints. Joints must be made of **approved** materials both for metal and other parts including the finishing materials for exterior and interior surfaces.

When not in the form of studs designed to be mounted with screws or bolts, they must have a substantial exterior metal casing insulated from both screw connections.

Fixtures

Mechanical Construction. Fixtures must be of metal or wood, except that other materials to be used must be submitted for special examination before being used. Materials other than metal must be reinforced by metal or the fixtures otherwise constructed to secure requisite mechanical strength.

In all fixtures not made entirely of metal, wire-ways must be metal lined unless **approved** armored conductors with suitable fittings are used. An exception is made in the case of wire-ways in glass, marble or similar non-absorptive, non-combustible insulating materials.

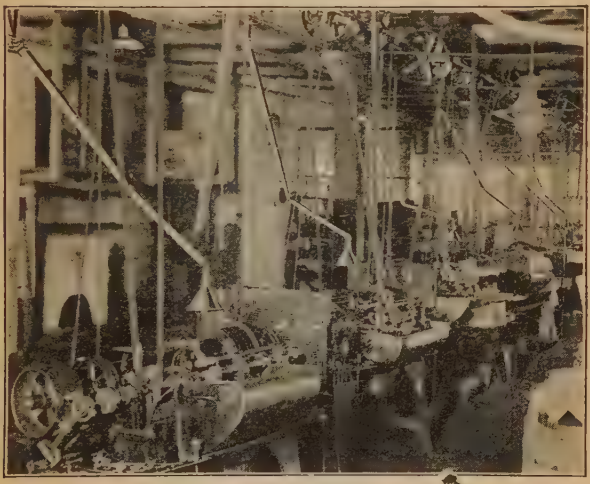
With screw joints of arms and stems there must be not less than five threads all engaging at fixture supports, fixture bodies, etc.

All methods of fastening arms, sockets and receptacles or making joints between metal parts by threading, soldering, brazing or otherwise, must be such as to secure in every case ample strength and reliability and to prevent turning.

SPECIFY

AMERICAN FIXTURES

ON YOUR NEXT INDUSTRIAL LIGHTING JOB



Boosting Production

That is the big thing that American Adjustable Fixtures accomplish when installed in your machine shop or factory. They bring the light to the work and enable higher intensities at low cost.

The "American" Fixture can be used for lighting any kind of work. Its construction is very substantial. All conductor wires are enclosed in the fixture arms. The universal joints enable the fixture arms to be moved in any position—and they stay put.

6 STYLES
Ceiling Fixtures
Wall Brackets
Floor Fixtures
Bench Fixtures
Machine Fixtures
Portables

Write to-day for details on the "American"

AMERICAN FIXTURE CO.

A. C. Runkel and Ed. R. Kiesslich, Proprs.

230 W. Water St., Milwaukee, Wis.

All burrs and fins in wireways must be removed and all sharp edges at points where wires emerge from arms, stems, chains, etc., must, when practicable, be removed or rounded, but in every case it must be possible to pull in and also to withdraw the wires without injuring them.

Where supply wires enter casings of fixture stems in either straight electric or combination gas and electric fixtures, there must be suitable fittings having smooth, rounded edges to prevent injury to the wire coverings and to prevent the wires from coming into contact with the edges of the ends of casings.

Fixtures for intallation outdoors or where exposed to moisture must be so constructed that water cannot enter the wireways, sockets or other electrical parts.

Electrical Construction. Conductors must be not smaller than No. 18 B. & S. gage.

On chains or similar parts where conductors are not completely enclosed in metal, the conductors must be stranded and must have rubber insulation not less than 1/32-inch in thickness. Wires and flexible cords must, when fixtures are externally wired, be so secured as not to be cut or abraded by the pressure of the fastenings or motion of the fixture, and must be protected against abrasion where they pass through sheet metal pans, canopies, etc.

Conductors must be so spliced or joined as to be both mechanically and electrically secure without solder. The joints must then be soldered (unless made with some form of **approved** splicing device) and covered with an insulation equal to that on the conductors, i. e., with both rubber and friction tape. Wires must, within the arms and stems, be without splices and taps.

Receptacles having exposed terminals must not be used in canopies unless completely enclosed in metal.

Materials. Tubing used in threaded arms and stems must not be lighter than No. 18 B. & S. gage. Tubing should not be kinked, flattened or cracked.

Canopies must be made sufficiently large, except where outlet boxes are used, to permit the storing away of splices to fixture leads and to allow supply conductors, and especially the splices to wires, to be kept clear of the grounded part of gas pipes.

Conductors used in wiring fixtures must be of approved fixture wire, approved flexible cord, or approved rubber covered wire, excepting that conductors having approved slow burning or other heat-resisting coverings must be used in wiring fixtures in which the wiring

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The Unit Without a Bad Habit

Glassware Pat. Mch. 6, '17

The Only Nitrogen Unit Made That Does Not Lose Its Efficiency Through Dust

Three sizes 10 x 4
13 x 6
16 x 6

Packed in Individual Cartons Coated

THE PHOENIX GLASS COMPANY

230 FIFTH AVE., NEW YORK

PITTSBURGH CHICAGO BOSTON

is exposed from the heat of the lamps to temperatures in excess of 120 degrees Fahrenheit (49 degrees Centigrade). All such forms of fixtures must be submitted for examination and test before being introduced for use.

All fixtures should, where possible, be sufficiently ventilated and the wiring should be so disposed as to avoid exposing the wiring to high temperatures.

Canopy insulators, if provided, must be of approved types. They must be securely fastened in place so as to separate the canopies thoroughly and permanently from the surfaces and outlet boxes from which they are designed to be insulated. A strip, of a good grade of hard fibre 1/16-inch thick, permanently attached to the canopy at the ends, and at intermediate points in such a manner that the strip will permanently extend at least 3/16-inch beyond the entire upper edge of the canopy rim will be acceptable. Where the above construction is impractical a sheet of a good grade of hard fibre 1/16-inch thick, permanently attached to the canopy and cut to conform to the general outline of the canopy and with the edges of the sheet at least flush with the edges of the canopy will be acceptable. The insulating strip or sheet must be secured by rivets or screws and the rivets or screws must be so located or countersunk that the desired effective insulation distance is obtained.

Rheostats, Resistance Boxes and Equalizers

Types. Rheostats used in dusty or linty places or where exposed to flyings of combustible material, must be so constructed that even if the resistive conductor be fused by excessive current the arc or any attendant flame will be quickly and safely extinguished. Rheostats used in places where the above conditions do not exist may be of any **approved** type.

Mounting. Rheostats must be so constructed that when mounted on a plane surface the casing will make contact with such surface only at the points of support. An air space of at least one-fourth inch between the rheostat casing and the supporting surface will be required.

Marking. The terminals of motor-starting rheostats must be marked to indicate to what part of the circuit each is to be connected, as "line," "armature" and "field."

Contacts. The design of the fixed and movable contacts and the resistance in each section must be such as to secure the least tendency toward arcing and

roughening of the contacts, even with careless handling or the presence of dirt.

In motor-starting rheostats the final contact, if any, on which the arm is brought to rest in the starting position, must have no electrical connection.

No-Voltage Release. Motor-starting rheostats must be so designed that the contact arm cannot be left on intermediate segments, and for direct current circuits must be provided with an automatic device which will interrupt the supply circuit before the speed of the motor falls to less than one-third of its normal value. In motor-starting rheostats for alternating current circuits the automatic interrupting device may be omitted.

Auto-Starters (Maximum of 100 Horsepower and 3,500 Volts). Under this class are included all such devices for starting A. C. motors as employ transformer windings whereby the potential impressed upon the motor terminals during process of starting may be made less than the full line voltage and which have switching devices for accomplishing the result.

Coils and switches of auto-starters designed for use in dusty and linty places or where exposed to flyings of combustible material, must be completely enclosed in substantial metal cases so constructed as to effectually exclude ordinary dust, lint or flyings of combustible material.

Auto-starters used in places where the above conditions do not exist may be of any approved type.

Cases for either transformer coils or switches must provides for access to the interior for inspection and for renewal of oil, and must be so constructed that when mounted on a plane surface the casing will make contact with such surface only at points of support. An air space at least one-fourth of an inch between the casing and supporting surface will be required.

The oil tank shall be marked in a suitable manner to indicate the proper oil level. When such device carries a visual oil indicator, the marking shall be for the proper oil level with the starter assembled. If the visual indicator is not used, markings shall indicate the oil level prior to assembling.

The switch must provide an off position, a running position and at least one starting position. It must be so arranged that it will be held in off and running positions, but cannot be left in a starting position or without the proper running overload protective devices in the circuit.

Reactive Coils and Condensers

Reactive coils must be made of non-combustible material, mounted on non-combustible bases and treated, in general, as souces of heat.

Condensers must be treated like other apparatus operating with equivalent voltage and currents. They must have non-combustible cases and supports, and must be isolated from all combustible materials and, in general, be treated as souces of heat.

Air-Cooled Trasformers

The following sections do not apply to transformers installed in central or sub-stations, outside of buildings, in fireproof vaults in buildings, nor to instrument transformers.

Mounting. Transformers must be so constructed that when mounted on a plane surface the casing will make contact with such surface only at the points of support. An air space of at least one-fourth of an inch between the transformer casing and the supporting surface will be required.

Approved transformers for bell-ringing and other signaling service only may be used provided all the wiring on the high voltage side is in accordance with Class C. The rating of the high voltage winding must not be over 250 volts.

Electric Signs (for Low-Potential Systems Only)

Material. Signs must be constructed entirely of metal or other approved non-combustible material, except that wood may be used on outside for decoration if kept at least two inches from nearest lamp receptacles.

Sheet metal must be not less than No. 28 U. S. metal gage.

All metal must be galvanized, enameled or treated with at least three coats of anti-corrosive paint, or otherwise protected in an **approved** manner against corrosion.

Construction. Signs must be so constructed as to secure ample strength and rigidity.

Must be so constructed as to be practically weatherproof and so as to enclose all terminals and wiring other than the supply leads, except that open work will be permitted for signs on roofs or open ground where not subject to mechanical injury, as hereinafter provided.

Transformers, unless of the weatherproof type, cut-outs, flashers, and other similar devices, if on or within

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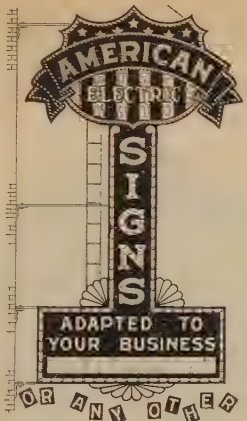
SELLING



Our local sales agents like to sell "American" electric signs because:—

"American" method of construction means strong, rigid weather proof qualities.

"American" oven baked enamel finish in any desired color means beauty next year as well as today and unlimited possibilities in color designs.

"American" electric signs are different; no two alike.

"American" methods make possible the exact illuminated reproduction of any trade mark or special style of lettering; this is not possible in the type of signs made from set patterns.

"American" electric signs comprise the three important types—lens letters, opal glass letters, lamp letters.

"American" Flashing effects in colors, aided by the use of colored lenses, make possible a variety of moving effects and colors which cannot be used by any other method.

"American" lenses in different sizes and colors make possible the illumination of the finest details in any object desired to be represented.

"American" artists and mechanics are unexcelled.

The **"American"** factory is the largest and best equipped exclusive electric sign factory in the world.

Our agents are prepared to meet the strongest competition. All of the efficient selling helps, colored illustrations, photographs, hand sketches, and necessary printed matter are furnished our agents without charge. Liberal commission.

We want one agent, preferably a representative of an Electric Light Company or an Electric Supply dealer, in every city and town where electric current is furnished.

Write for our "Rays of Light" booklet, containing over fifty illustrations in colors and special proposition to agents.

AMERICAN SIGN COMPANY
KALAMAZOO, MICHIGAN

Turn Your SIGNS On or Off

with the

HARTFORD TIME SWITCH

Wind Once a Week

Then Let It Alone

"It Works While the Watchman Sleeps"

THE OFFICIALLY APPROVED SWITCH
THAT GETS THE INSPECTOR'S "OK".

SEND FOR CIRCULARS

THE HARTFORD TIME SWITCH CO.

71 MURRAY STREET NEW YORK

A. HALL BERRY, General Sales Agent

the body or structure of the sign, must be in a separate, completely enclosed, accessible weatherproof box or cabinet of metal of thickness not less than that of the metal of the sign itself.

The above devices if otherwise located must be enclosed in approved cut-out boxes or cabinets.

Each compartment must have suitable provision for drainage through one or more holes each not less than one-quarter inch in diameter.

Receptacles. These must be so designed as to afford permanent and reliable means to prevent possible turning; must be so designed and placed that terminals will be at least one-half inch from other terminals and from metal of the sign, except that where open work is permitted this separation must be one inch.

Miniature receptacles will not be approved for use in outdoor signs.

Wiring. Wires must be approved rubber covered, not less than No. 14 B. & S. gage.

They must be neatly run, and so disposed and fastened as to be mechanically secure.

Must be soldered to terminals, and exposed parts of wires and terminals must be treated to prevent corrosion.

Must, where they pass through walls or partitions of the sign be protected by approved bushings.

On outside of sign structure, except where open work is permitted, wires must be in approved metal conduit or in approved lead sheathed armored cable.

For open work, wire must be rigidly supported on non-combustible, non-absorptive insulators, which separate the wires at least one inch from the surface wired over. Rigid supporting requires, under ordinary conditions where wiring over flat surfaces, supports at least every four and one-half feet. If the wires are liable to be disturbed, the distances between supports should be shortened.

For open work in those parts of circuits where wires are connected to approved receptacles which hold them at least one inch from surface wired over, and which are placed not over one foot apart, such receptacles will be considered to afford the necessary support and spacing of the wires. Between receptacles more than one foot, but less than two feet apart, an additional non-combustible, non-absorptive insulator maintaining a separation and spacing equivalent to the receptacles must be used. Except as above specified, wires must be kept apart at least two and one-half inches for voltage up to 300, and four inches for higher voltages.

Leads from sign must pass through the walls of sign either through **approved** metal conduit or armored cable, or must be neatly cabled and pass through one or more **approved** non-combustible, non-absorptive bushings.

Not over 1,320 watts shall be dependent upon final cut-out.

House Wiring

Special Suggestions and Recommendations to the House Owner, Architect, Contractor and Wireman, in Accordance with the Rules and Requirements of the National Electrical Code.

Obtaining Service

In every case where the electric wires have not been introduced into a house it is necessary to consult the central station as to the terms on which service can be obtained.

When the wires are not even on the street it will always be necessary for the central station to make an extension, involving additional mains, as the electric wires in the street are called, and usually additional poles for overhead wires, or digging for conduits for underground wires.

It may be noted here that the current for trolley service is not suitable for house lighting, nor is such service allowed by the insurance interests in any part of the country.

No one but the central station representative can determine the cost of making an extension, and all that can be said in this general treatise is that sometimes the central station will extend its wires without any guarantee, on the chance that the new business will be profitable. In other cases the prospective customer is asked to guarantee a definite income for a term of years, or to make a deposit towards the cost of the extension, to be returned out of the income; or, in extreme cases, even to pay the whole cost. Each case has to be considered separately; but in this country a somewhat general rule is to make extensions when the annual income, either estimated or guaranteed, is equal to about half the cost of the additional investment, or cost of the extension beyond the point to which the lines have been already built.

In regard to whether the service is overhead or underground, this usually depends on the character of the neighborhood, dense city districts being supplied underground, and suburban or country districts overhead.

If in a district where the wires are underground, the central station extends the mains along the street, and usually branches from the mains to the lot line without further charge for the branch. Sometimes the street construction is such that the house service comes from the main directly opposite. In other cases there are manholes in the street at convenient intervals, and the wires run directly from such manhole to the house.

Sometimes a charge is made by the central station for the whole of the branch to the house, but more usually there is no charge for the work in the public streets, and often the wire is carried free to the house wall, especially if the house is close to the street. If, however, there is a wide lawn a charge is often made, running from 75 cents to $1.50 or more per foot, according to the then prevailing cost of labor and materials, or the circumstances. In the case of new houses it is often convenient to use the same trench or conduits for the telephone wires also, and sometimes even for the water pipe.

As the central station will always either do this underground work itself or furnish definite and complete specifications, no further reference need be made to it here.

In the case of overhead wires questions about the extension of the central station wires in the street come up. The householder should appreciate that overhead wires are installed only in districts where the cost of underground is prohibitive, so that if the central station cannot obtain the right to set the necessary poles in such districts it may not be able to extend the wires at all.

When the necessary poles are near enough the central station will usually run the wires from the pole to the house without further charge, including the necessary transformer where alternating current is used.

In other cases, as when the house sets far back, or when for some special reason the wires have to enter the house in the rear, it may be necessary to set poles on the private property, for which work the central station will frequently make a charge for

each pole together with the wire, cross arms, insulators, etc.

Of course, when the customer is willing to pay for it, the central station will run its wires down the pole into the ground and supply the house by an underground service, even in overhead districts.

Although not specified in the Code, bare wires are sometimes used, especially through uninhabited and isolated territories, free from other wires.

Bare wire is also used for high tension lines, the theory being that only the insulators and not the covering are relied on for pole insulation. Hence, where there is no danger of other wires or trees coming near them, bare wire is satisfactory. If there are other wires or trees near, and the potential is below say 5,000, then weatherproof insulation saves enough trouble from crosses with other wires, branches, etc., to be worth the cost. When, however, the voltage is above 5,000, the protection of the covering is so slight as not to be worth while.

It should be noted that wires should be kept well clear of trees, as branches may blow onto the wires and cause trouble, even if clear of the wires in calm weather.

Also, many companies consider it undesirable to attach wires to trees, but prefer to set independent poles, even at an added expense, on the ground that in the long run the cost is less. Where tree wiring may be necessary, suggestions are illustrated on page 250.

Guard arms should be placed on all corner poles (see pages 247 and 248).

This, however, applies more often to poles on street corners rather than from pole to house.

In alternating current systems the wires in the street are usually of high voltage (2,000 to 4,000 volts) and a transformer is used for transforming the voltage to 110 or 220 volts.

The rule governing transformer installation is given on pages 91 and 253.

Current Supply

Art. 1: In designing a house wiring installation it is necessary to know whether the current is direct or alternating and the voltage of the supply service. If alternating it is also necessary to know the phase and cycles.

In some large cities direct current is used and also

in places where owners have private generating plants. In most of the intermediate and smaller cities, however, and in practically all suburban districts, the supply is from alternating current.

In practically all residences, except very large ones with large individual motors, the alternating current is delivered in what is known as single phase, requiring but one transformer, and this condition is assumed throughout this section of the book.

The transformer for supplying a residence is generally located on a pole, or in an underground vault, near, or inside, the building, and the transformer is designed with two or three wires, according to the system used, coming from it on the house or service side.

The Code rule is as follows:

Transformers must not be placed inside of buildings without special permission.

Must be located as near as possible to the point at which the primary wires enter the building.

Must be placed in an enclosure constructed of fire-resisting material; the enclosure to be used only for this purpose, and to be kept securely locked, and access to the same allowed only to responsible parties.

The transformer case must be permanently and effectually grounded (see page 101), and the enclosure in which the transformers are placed must be thoroughly ventilated to the outdoor air, if possible, through a chimney or flue. There should be at least six inches air space on all sides of the transformer.

In equipments with not more than fifty lights and outlets many lighting companies deliver the current, from the transformer to the building, on a two wire system at about 110 volts and without the use of the third or neutral wire.

Voltage

Art. 2: With the three wire system the voltage between the two outside wires is generally about 220 volts and the voltage between the neutral (middle) wire and either outside wire is about 110 volts. The 110-volt outlets, for lights and small appliances, are placed on two wire branch circuits, balanced on each side of this neutral wire. Larger appliances are often wound for 220 volts and connected across the outside or 220-volt circuit.

For these larger power appliances and motors 220-volt apparatus is used for the purpose of reducing the size of the wires supplying them. Small heating appli-

ances where considerable heat must be generated are almost universally made for 110 volts.

Bell and telephone systems require but low voltage (4-6 volts) and small currents, and therefore are seldom dangerous from a fire standpoint when kept away from contact with light and power wiring. This portion of the installation is not inspected by insurance representatives, except to see that the wires do not come in contact at any point with electric lighting or power circuits, from which they must be kept entirely separate.

Service Feeders

Art. 3: In most of the larger cities the feed wires come directly into the cellar underground and in many cases where the wires are overhead on poles, the owner prefers to have the wires brought into the house underground from the nearest pole, although in this case, the owner usually pays for the underground portion of the work.

Where the lighting company's pole on the highway is not over sixty or seventy feet (60′ or 70′) from the residence, the central station company will generally bring its service wires overhead to the house without charge, and in such cases it is good practice to have the house wiring carried through the cellar wall to the outside of the house and then rise in a rigid iron conduit (see page 96) to meet the overhead wiring, the end of the conduit being turned over or fitted with an appliance such as a service head or pot-head which will prevent the entrance of water (see page 252).

At this point insulators are placed on the side of the house to take the strain of the wires from the pole to the house, and then a loop is made, connecting to the wires in the conduit, arranged so that the wires come out of the conduit at a downward angle to prevent rain water from running along the wires into the conduit.

Main Switch and Meters

Art. 4. The service switch (see pages 31 and 252) for cutting off the entire electrical supply of the house, and the meters, usually furnished and installed by the lighting company, should be located at some accessible point as in the cellar close to where the wires come through the wall. This makes it unnecessary for the meter reader, who comes once a month, to go through the main living portion of the residence (see pages 108 to 114).

Where different rates are charged for different classes

of service there should be a different meter for each class. Many service companies make different rates for light, for power and for heating, cooking and refrigeration. Most companies will furnish and connect three-wire meters for power and cooking, etc., as well as for light, so that both 110-volt and 220-volt apparatus may be used on the same meter by balancing on each side of the neutral wire, as explained in Art. 2. The service company should be consulted as to meter arrangements.

Current Costs

Art. 5: The rates for current, usually governed and regulated by the public service commissions of the particular districts under their jurisdiction, necessarily very greatly in different parts of the country, and are based on the costs of location, labor and the power (oil, coal or water-power) used.

Rates in some localities are based on a sliding scale according to the minimum demand. Electricity is sold at so much per kilowatt-hour. A kilowatt means 1,000 watts.

A kilowatt-hour is the equivalent of 1,000 watts continually consumed for one hour. Watts are the product of the volts by the amperes. Thus, 40 25-watt Mazda or Tungsten lamps (each giving about 24 candle-power) all continuously in use for one hour, or one such lamp burning for 40 hours would in either case consume one kilowatt-hour. (See lamp data, page 366.)

For cooking, current at 3c. per kilowatt-hour is about the equivalent of artificial gas at 90c.

Grounding

Art. 6: In two-wire system (see Art. 1), one side of the service switch and in the three-wire system, the neutral (middle) of the service switch (in both cases on the incoming side), should be grounded by means of a copper wire to the water supply pipe on the supply side of the water meter.

By grounding (see pages 101 to 107) is meant a solid, permanent connection to the earth or ground by means of connection to water pipes, or plates buried in the ground. The result is that if either outside the house or in it anyone touches this neutral or grounded wire, as at a lamp socket, and also touches or makes connection with the ground, as through a gas pipe or radiator, there is no difference of potential, while if either the positive or negative wire is touched only, the system potential, as 120 or 240 volts, is felt, and is

considered perfectly safe while pressure above 300 become dangerous.

Without a ground connection, it is possible, in case of an accident in the street or during a thunder-storm, for almost any pressure to get on the wires. If this happens they are still safe so long as no connection is made by a person between the wires, and no ground connection made at all. If after such dangerous pressure gets on the wires a ground connection is made somewhere by accident, still nothing happens, but then if a person touch the ungrounded wire and connect to ground, as through a radiator, etc., he gets the full pressure.

On the other hand, with a ground connection made intentionally, whenever any dangerous pressure gets on the wires it immediately flows to the ground, when contact is made, through any lamp socket, motor, or current-using devices on the system, and usually blows the fuses before any harm can be done.

The result is that a ground connection, while making it possible for any person easily to get the normal voltage, makes it impossible for him to get any more.

Caution: Avoid, if possible, touching or coming in personal contact with any wiring of any sort (lighting, power or telephone), connected in any way with outside overhead conductors just before, during or just after the passage of a thunderstorm.

Where the wiring of the house is in conduit, the conduit system should be continuous or electrically connected by means of wires, and the conduit system also grounded in the cellar to the water pipe, in the same manner as described above for service switches. The two ground wires should be separate, although they may connect to the same water pipe.

House Mains

Art. 7: From the service equipment the supply wires, called the mains, should be carried to the central distributing points (known as cut-out or panel equipments), there being one such main for each class of equipment that is separately metered (see Art. 4). These mains are carried to all panel equipments controlling the class of appliance which the mains are intended to supply. The branch circuits which run to light and power outlets and to the various appliances radiating from these panel equipments, should be located in central and accessible positions. (To find the proper size of wires, for ordinary installa-

tions, for carrying any current any distance for any number of lamps, or their equivalent, at any loss of voltage (see table and examples on pages 6 to 14).

Distributing Panels

Art. 8: In residence work it is good practice to place the distributing panels in cellars, servants' halls or corridors (not in clothes closets) so that workmen can get to them when necessary without disturbing the occupants of the house, and where possible dirty shoes and hands will do the least damage. The necessity, however, does not often occur in well designed and installed systems.

These panel equipments may consist of groups of porcelain cut-outs and fuses or porcelain base knife switches and fuses. In the best class of work knife switches and enclosed fuses are mounted directly in two vertical rows on polished slate or marble panels and cross connected by metal straps to polished copper bus-bars rising up the middle of the panel. These bus-bars are fitted at their ends with lugs to which the mains connect. The cut-outs or panel are surrounded with slate edgings containing openings through which the circuit wires pass to connect to the branch switches. The slate frame thus formed is mounted in a metal box with from three to four inches (3" to 4") space around the slate, thus forming a gutter in which the circuit wires can be carried to the switches from the ends of the conduits terminating in the metal box. If a wooden door is used it should be lined with slate, and any wood trim which covers the gutter and overlaps the joint between the box and wall should be lined with metal on the under surface covering gutter. Where metal doors and trims are used only the slate door lining is required. These trims are usually from 24 to 28 inches wide and of varying lengths to suit the number of circuits.

Each panel circuit or switch should be numbered by means of a metal stamp on the bus-bars opposite the switch and a directory sheet should be placed on the inside of the door giving the number of each switch and the number and location of the lights controlled. There should be a separate double pole cut-out or switch and fuses for each circuit consuming 660 watts or less in the case of lamps or small power and heating devices; and a similar cut-out and switch for each outlet for motor, etc., where the capacity is greater than 300 or 350 watts (see Art. 9).

Where more than one main feeds a panel in bus-bar

construction, the bus bars are cut into the required number of sections and each section carried out between switches to the edge of the panel, so that the main wires may be joined to the bus-bar ends just inside the slate edge and without the necessity of having the wires cross the panel.

To limit the necessity of cutting away too much of walls, floors and supports, where circuit conduits come together, the number of circuits at any panel box should be limited to ten or twelve by placing as many boxes at separate locations as may be necessary to supply the residence. Where the building construction will permit, however, as many as eighteen to twenty-four circuits may be grouped at a single panel without causing the cabinet to be prohibitive in size.

Branch Circuits

Art. 9: The rules of the Fire Underwriters allow 660 watts distributed at sixteen sockets on each two wire lighting circuit. It is recommended, however, that the number of sockets be limited to twelve or thirteen on a circuit, as this does not greatly affect the cost of the work and will permit the use of No. 14 wire for practically all such branch circuits without undue loss in voltage and without appreciable variation in voltage between outlets on the same circuit under any condition of use. (See Carrying Capacity of Wires, page 91.)

Branch circuits for single phase power are also two-wire and vary in size depending on the horsepower of the motor or the watts of the appliance connected (see page 81).

In wiring for small motors from one-half H. P. to 1 H. P. branch circuits should be No. 14 wire for 220-volt motors and No. 12 wire for 110-volt motors. These sizes are made necessary because of the large inrush of current at the moment of starting the motor. For other appliances where there are no moving parts (such as electric soldering irons) the size of the wires varies with the watts consumed, but in no case should such wires be smaller than No. 14 Brown and Sharp gauge (see page 91, 5th column). Where heating devices are of small capacity, as glue pot and soldering iron in basement workshop, two or more may be placed on one circuit. Where the wattage of a single appliance is 350 watts or more it is better to carry a separate circuit to each such appliance.

The branch circuits to electric cooking ranges are generally three-wire; the size depending on the capacity of the range (see page 95 to 98).

The branch circuit for the vacuum cleaner outlets should be on the power section of the system, and as but one outlet is used at a time all the vacuum cleaning outlets in the residence may be placed on one No. 12 wire branch circuit and connected for 220 volts.

Where the lighing companies make separate rates (as in Art. 4) branch circuits to lighting appliances, to power appliances, and to heating appliances must, of course, be kept separate and connected to the proper section of panel equipments and to their own particular meters.

Knob Work with Flexible Non-Metallic Conduit

Art. 10. In a frame residence with stud partitions, it is permissible to carry wires on porcelain insulators on the sides of the beams and studs and through them by enclosing in porcelain tubes with flexible non-metallic conduit (flexible tube) from nearest knob to outlet keeping the wires as far as possible from the floor or ceiling to prevent injury. Outlet boxes should be used for flush switches and receptacles; but for ceiling and side fixture outlets where there are no gas pipes and for surface switches and receptacles, wood fixture blocks should be built into the walls and securely fastened to beams and studs to give adequate support for the fixtures and fittings. This type of construction is known as "knob and tube" work and is not only the cheapest but also a very satisfactory method of installation for concealed wiring in residences (see pages 56 and 58).

New York and Chicago, however, do not permit knob and tube work.

Armored Cable

Art. 10a: Some architects and engineers specify armored cable for frame or semi-frame residences (pages 125 and 127). This armored cable is made by wrapping steel tape or ribbon around the two or more wires of the mains or circuits, thus giving a heavy metal sheathed main or branch circuit. Such cable is made in lengths of from 50 to 250 feet. Armored cable may be laid or drawn between beams and studs or furring strips with practically no liability to mechanical injury from nails, etc. Armored cable should not be placed in brick or concrete walls unless imbedded in plaster-of-paris or other suitable material to protect the sheath and wires from the corrosive action of the surrounding ingredients. For the same reason the best practice prohibits such armored cable being placed in brick or concrete walls where subject to considerable

dampness. Outlet boxes in this construction are re-grounded as called for in Art. 6.

Armored cable may be placed in damp locations if a lead sheath exists between the insulation and the armor.

Armored cable construction is very satisfactory in residences where the permanent decorations are not expensive or where the construction is such that the concealed lengths between outlets may be withdrawn and new lengths drawn in (in case of trouble) without injury to the finished surface. This construction is a little more expensive than knob and tube work (see Art 12).

Flexible Steel Conduit

Art. 10b: Where the character of a residence is such that it would be expensive to make repairs or alterations in the concealed wiring, good practice calls for the use of concealed conduits for the reception of wires. These conduits should be large enough to permit the easy drawing in and withdrawal of the wires without the use of tackle. The smallest conduit generally used for electric light branch work is about one-half inch inside diameter. Conduits should be securely fastened to building construction and have easy bends to facilitate the drawing in of the wires. Flexible steel conduit is frequently used for this purpose, the construction of which is practically the same as armored cable, but without the cables. These flexible conduits are made in lengths of from 25 to 100 feet for lighting work and this type of wiring installation is more expensive than armored cable (see Art. 12). Flexible conduits are particularly suitable for the wiring of old buildings, where rigid conduits could not be installed without too much damage to plaster and decorations.

Rigid Conduits

Art. 10c: For the highest class of residence work, architects and engineers generally specify rigid conduit construction (see page 64). These rigid conduits are of gas-pipe thickness and are coated on the inside with a tough, elastic and very smooth enamel. The exterior may either be coated with the same enamel or galvanized. The conduits come in ten-foot lengths and all diameters from half-inch to six-inch and are joined by means of screw couplings of the same material, and the joints are made tight by the use of red or white lead. This prevents the entrance of any moisture. This is the most expensive character of concealed wiring work, but in the higher and more expensive

class of buildings, where walls, floors or ceilings can not be opened up without great expense and there is danger of ruining expensive decorations, it is the only kind of construction that should be considered (see Art. 12).

Wood Raceway

Art. 10d: This class of work, which is not permitted in concealed places, is frequently resorted to on account of its cheapness and where it is unnecessary for appearance sake to run circuits inside of walls or ceilings. Wood raceway work is especially adapted to the cheaper class of cottages, bungalows, etc. For construction rules see pages 52-54).

Cleat Work

Art. 10e: In dry places and where the wires are not liable to mechanical injury or contact with other objects circuits may be supported on porcelain cleats or knobs.

For this class of work the wires should be separated, by their insulating knobs or cleats, two and one-half inches from each other and at least one-half inch from the surface wired over (pages 90 and 133), where the voltage does not exceed 300, and four inches from each other and at least one inch from the surface wired over where the voltage does not exceed 550.

Metal Raceway

Art. 10f: Where it becomes necessary, for mechanical reasons, to use metal raceways the suggestions given on pages 82 and 152 should be followed.

Bell Conduits

Art. 10g: Bell and telephone cables and wires need not necessarily be in conduit nor need they be installed on knobs. In fireproof or semi-fireproof residences where the cables come in contact with brick or concrete and would not last, and in frame residences where it is desired to make repairs to the concealed wiring without injury to the walls, such wires should be placed in concealed conduits, installed in the same manner as described above for electric light wiring. In the best class of residence work this is usually done.

Conduit Fittings

Art. 11: In both armored cable and metallic conduit construction special fittings are used to connect the metal to the outlet box or cut-out box, or other opening, and bushing or nipples are so designed and installed that the wire is drawn over or rests on smooth rounded surfaces to prevent abrasion of the braided covering of the conductors.

Approximate Wiring Costs

Art. 12a: Due to the varied cost of labor and material and to varying methods of building construction, universal costs of electric light work for the several types of wiring hereinbefore described cannot be given, but for the purpose of general comparison the following approximations may be a help by showing proportional costs of the various systems:

Knob and (Flexible) Tube Work	$2.00	to $3.50	per outlet
B. X. Cable Work	3.00	to 6.00	" "
Flexible Steel Conduit Work	4.00	to 7.00	" "
Rigid Metallic Conduit Work	5.00	to 8.00	" "

It must be borne in mind, however, that these proportions for the wiring work will not follow as proportions for the complete equipment, as the cost of fixtures, appliances and lamps, etc., will be the same for any one of the systems, and as these fixed costs are generally the larger part of the complete total the above proportions would apply to perhaps one-half or less of the total cost of any given installation.

Bell Costs

Art. 12b: Call bell or annunciator requirements differ for almost every family and attempts to give costs in this class of work would be misleading. In a general way, however, the equipments will range from $3.00 to $10.00 per call; and from $1.50 to $8.00 per extension bell or annunciator drop. The smaller costs are for the simpler systems with concealed wires not in conduits, and the higher costs for more or less complicated call systems with wires in concealed rigid conduits.

House Telephone Costs

Art. 12c: A house telephone system intercommunicating between various rooms of the residence and arranged on what is known as metallic circuit connections (to prevent cross-talk) will cost from $20.00 to $50.00 per instrument, depending upon the number and finish of the instruments, and whether or not the concealed wire is in conduit. Most of the telephone manufacturers of this class of instrument make a standard telephone with ten (10) buttons, thus providing for intercommunication between eleven (11) points.

Wire for Light and Power

Art. 13a: All of the various fire underwriters organizations require "rubber covered" wire (see page 117) for all classes of concealed residence wiring. These wires have a single impregnated braid for No. 8 and smaller sizes, and a double braid for larger sizes. The life of rubber insulation depends largely upon the amount of

pure unreclaimed Para rubber used in the insulating compound and the method of applying it to the copper conductor. The very best class used in residence wiring as well as the most expensive contains about 30 per cent. pure Para rubber (see specifications, page 117).

In installations supplied by alternating current it is important that all the wires of any branch circuit, main or feeder should be in the same conduit. In fact, this should be absolutely insisted upon to prevent trouble from induction. Joints in wires should not be allowed where they will be concealed in conduits or be at inaccessible points. Where splicing is necessary the joint should first be made mechanically strong, then soldered for perfect electrical contact (unless approved solderless connector is used) and insulated with rubber compound and tape and made equal in insulation to the rest of the wire (see page 247).

Bell and Telephone Wire

Art. 13b: Wire used in bell and telephone systems may be of the same quality as above described, but need not be as large in size. For small bell systems No. 18 B. & S. gage is amply large for the section wires and No. 16 for the battery wires. These sizes are determined mainly by considerations of mechanical strength and in order to easily distinguish between battery and section wire.

Where there are a number of bell or telephone wires carried between two points a considerable distance apart, it is quite customary to buy the cable already made up, and these wires are often as small as No. 20 or No. 22 B. & S. gage. The separate wires in such cables may be insulated with two silk and one cotton wrapping impregnated with beeswax to keep the ends of the yarns from unraveling and the made-up cable encased in a heavy fireproof braided covering.

The most approved type of house telephone contains two wires for each call, two wires for battery talking, two wires for battery ringing. Each pair of wires should be twisted to prevent "cross-talk." This refers to metallic circuit connections in house intercommunicating telephone systems. Where silk and cotton cables are used in damp places the cable should be encased in lead to prevent moisture developing short circuits between the various wires.

Voltage Loss in Conductors

Art. 14: The size of conductors given in the National Electrical Code for any given current is based only on

the safe carrying capacity (see table, page 91) without undue heating and does not necessarily determine, except where the distance is short, the size of conductor that good engineering practice requires. The proper size of conductors in any installation should be determined by the loss in volts between the service supply and the furthest outlet or appliance (electrically speaking) when the entire equipment is in simultaneous operation. In residence work two per cent. loss between the above mentioned points is not excessive (see pages 6-14). Conductors smaller than No. 14 Brown and Sharp gage must never be used in electric light work, except inside the lighting fixtures where a smaller conductor is permissible.

In proportioning the total voltage losses of a residence installation between the mains and branch circuits not more than one per cent. loss should be permitted in the branch circuit panel. A simple table, with examples worked out, to show its use, is given on pages 79 to 82. By its use the proper size of wire is easily determined for carrying any current any distance at any desired loss in volts.

There is a large rush of current at the moment of starting up single phase alternating current motors, and the loss in such wires should be based on this momentary large amount which may vary from 100 to 200 per cent. overload of current. If this condition is not provided for it is quite possible to install wires that would be large enough to operate the motor after it is in motion, but too small to take care of this starting current.

Room Switches

Art. 15a: A liberal use of switches in a residence invites economy by encouraging the putting out of lights when leaving rooms. They soon pay for themselves. The most satisfactory switches are of the flush type and should be placed in metal boxes sunk in the wall and should generally be located just inside of entrance doors.

Large rooms with numerous outlets should be controlled by more than one switch, and in long living rooms it is often a good plan to place the lights of each end of the room on a different switch control, both for convenience of occupants and economy in bills.

For electroliers switches are sometimes used, so designed that one turn of the handle lights one group of lights; the second turn lights an additional group

without putting out the first group, and a third turn will put all out.

Servants' rooms should have switches and high fixtures not only so that the lights will be more apt to be extinguished when not needed, but also to prevent the use of fixtures as clothes hangers.

Hall Switches

Art. 15b: For hall and stairs it is customary to arrange lights so that they may be turned on or off from any one of several switches known as three-way and four-way switches. A light in first floor hall and one on the second floor may be controlled by a switch at entrance door and also controlled from second floor. In the same manner an outlet on third floor may be controlled by a switch in second hall and one on third floor. This allows a person going to the third floor to come in late, light halls and stairs to room and put out lights again from above and thus do away with wasteful burning (see Hall Wiring, page 210).

The three-way arrangement for servants' stairs especially will keep down the monthly bills, because of the ease with which the servants can put out lights. Sometimes this three-way switch arrangement is used in bedrooms, one switch at door and the other at bed.

Master Switch

Art. 15c: A master switch may be placed in the owner's bedroom and so connected that the switch will control the first, second and third floors, main hall and stairs (three-way lights), independent of whether the local switches are "on" or "off" (see Master Bedroom, page 211).

Closet Switches

Art. 15d: Closet switches are often controlled by switches set in the door jambs and operated by movement of door. As closets, however, are often left open for ventilation, wall switches are preferable.

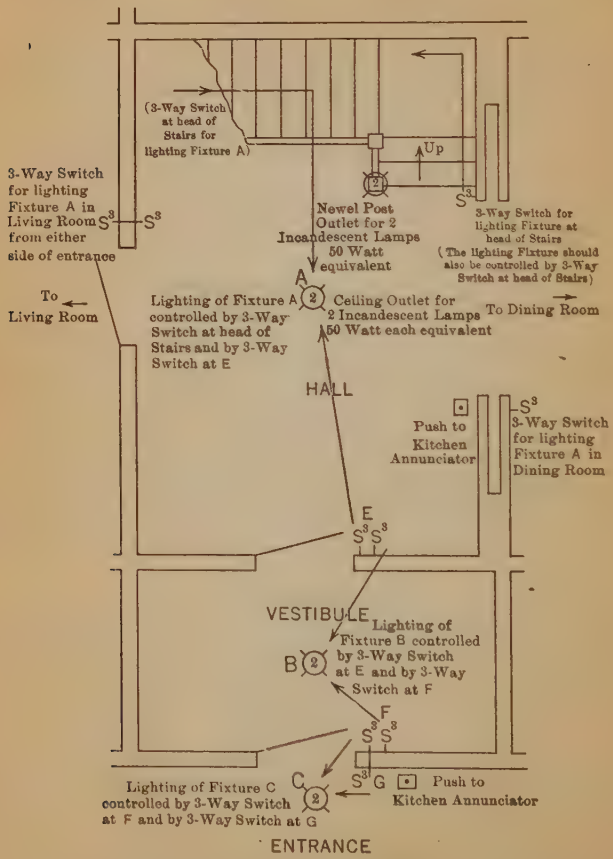
Pilot Switches

Art. 15e: With switches operating lights not visible from the switch (as in case of cellar) it is economical to equip the switch with a small pilot light which burns when switch is in use.

The same style of pilot switch should be used in connection with all heating or other appliances which are fixed in position and do not visibly indicate when current is one (see Art. 18).

Motor Switches

Art. 16: Fused knife switches (see page 156) in metal boxes should be used in connection with A. C. motors of one-half H. P. and larger. These switches

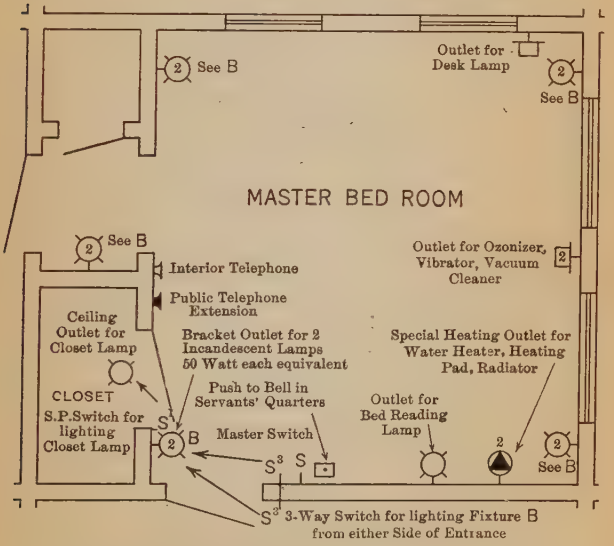

(3-Way Switch at head of Stairs for lighting Fixture A)
Up
3-Way Switch for lighting Fixture A in Living Room from either side of entrance
S3
S3
Newel Post Outlet for 2 Incandescent Lamps 50 Watt equivalent
S3
3-Way Switch for lighting Fixture at head of Stairs
(The lighting Fixture should also be controlled by 3-Way Switch at head of Stairs)
To Living Room
A
2
Lighting of Fixture A controlled by 3-Way Switch at head of Stairs and by 3-Way Switch at E
Ceiling Outlet for 2 Incandescent Lamps 60 Watt each equivalent
To Dining Room
HALL
Push to Kitchen Annunciator
S3
3-Way Switch for lighting Fixture A in Dining Room
E
S3 S3
VESTIBULE
Lighting of Fixture B controlled by 3-Way Switch at E and by 3-Way Switch at F
B
2
F
S3 S3
C
2
Lighting of Fixture C controlled by 3-Way Switch at F and by 3-Way Switch at G
S3
G
Push to Kitchen Annunciator
ENTRANCE

should be double pole and located near the motor they control. Motor starting boxes are sometimes used

with one-half H. P. to 1 H. P. A. C. single phase motors in order to cut down the momentary rush of current (described in Art. 14), but nearly every service company will permit motors to be operated directly from the switch. Small motors may be operated from flush lighting switches.

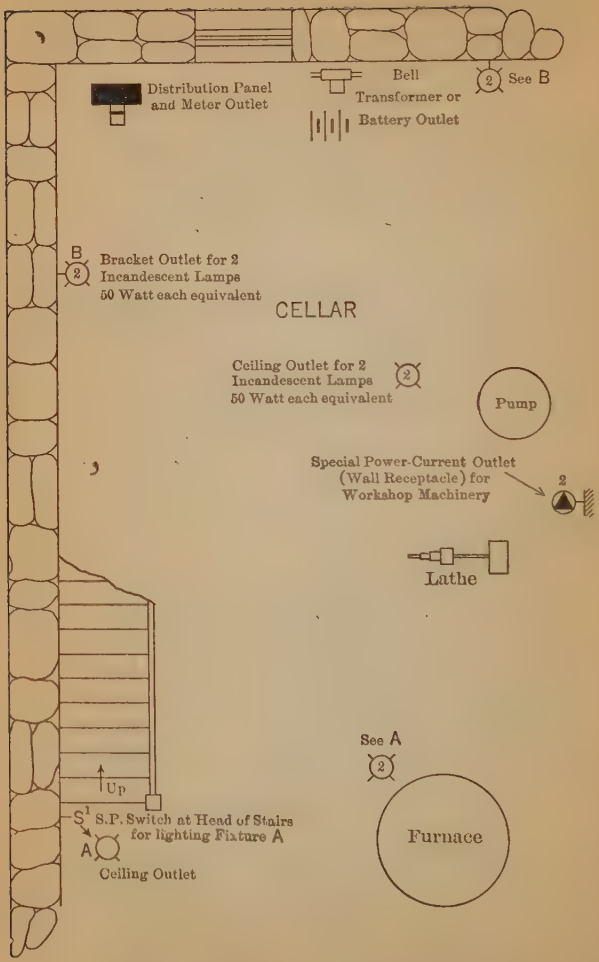
Tank Switches

Art. 17: When the house water tank in the attic is filled by an electric pump, a switch should be placed at the tank and connected to a float in the water, and so wired and connected as to automatically start and stop the pump by the fall and rise of the water in the tank.


See B
Outlet for Desk Lamp
See B
MASTER BED ROOM
See B
Interior Telephone
Public Telephone Extension
Outlet for Ozonizer, Vibrator, Vacuum Cleaner
Ceiling Outlet for Closet Lamp
Bracket Outlet for 2 Incandescent Lamps 50 Watt each equivalent
Special Heating Outlet for Water Heater, Heating Pad, Radiator
CLOSET
Push to Bell in Servants' Quarters
S.P.Switch for lighting Closet Lamp
Master Switch
Outlet for Bed Reading Lamp
See B
3-Way Switch for lighting Fixture B from either Side of Entrance

Combination Pilot Switch and Receptacle

Art. 18: Where portable electrical appliances do not visibly indicate when the current is on, and where such appliances are connected by means of flexible wires, the wall outfit should consist of a switch pilot light and receptacle. All three (3) may be placed in the same outlet box and one (1) plate covers all.


Distribution Panel and Meter Outlet
Bell
Transformer or
Battery Outlet
2
See B
B
2
Bracket Outlet for 2 Incandescent Lamps 50 Watt each equivalent
CELLAR
Ceiling Outlet for 2 Incandescent Lamps 50 Watt each equivalent
2
Pump
Special Power-Current Outlet (Wall Receptacle) for Workshop Machinery
2
Lathe
See A
2
Furnace
Up
S1
S.P. Switch at Head of Stairs for lighting Fixture A
A
Ceiling Outlet

Base Receptacles

Art. 19a: Flush receptacles and plugs should be liberally distributed throughout the residence as they are very handy for a great variety of purposes and may be generally placed on or just above the baseboard. The plates may be painted to match surroundings and made very inconspicuous.

Receptacles for the same voltage and class of service should have interchangeable plugs to avoid the necessity of changing the plug on the flexible cord attached to any lamp or appliance should its location be changed.

Receptacles, however, should be so designed that the plugs on apparatus of different voltage or class cannot be inadvertently connected to wrong receptacles. This may be accomplished by using the same make of receptacle with different openings for each voltage or class or by specifying a different make for each class. If this is not done, a 110-volt appliance might be easily connected to a 220-volt receptacle, in which case the appliance would probably be destroyed, to say nothing of the fire hazard involved.

Receptacles for lighting purposes are usually 110 volts.

In addition the lighting receptacles which are usually installed for reading lamps, piano lamps, etc., there should be one or two spare receptacles in each main room and hall. One of the receptacles in main living room or hall should be placed so as to be near a suitable location for a Christmas tree or portable stand lamp, so that this may be illuminated without unsightly wires showing in the room. Very few dwellings are sufficiently equipped with receptacles, and the occupants resort to the dangerous practice of stapling flexible cords to walls and trim.

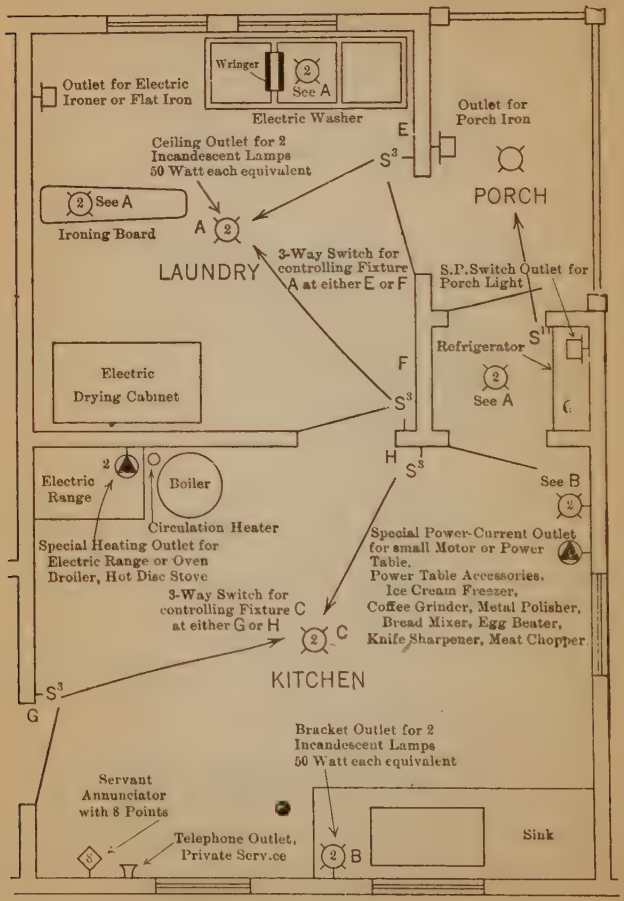
This means YOU!

A porcelain lamp receptacle, mounted in a condulet or outlet box, is often placed under the kitchen range-hood and the conduit run around under the hood to the side wall where the controlling switch is located.

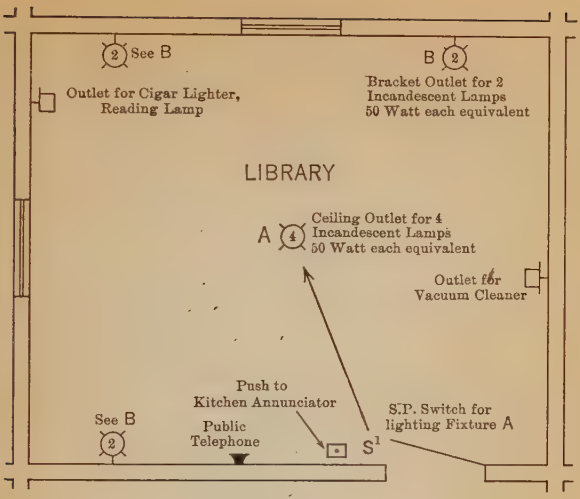
Outdoor Decoration Receptacles

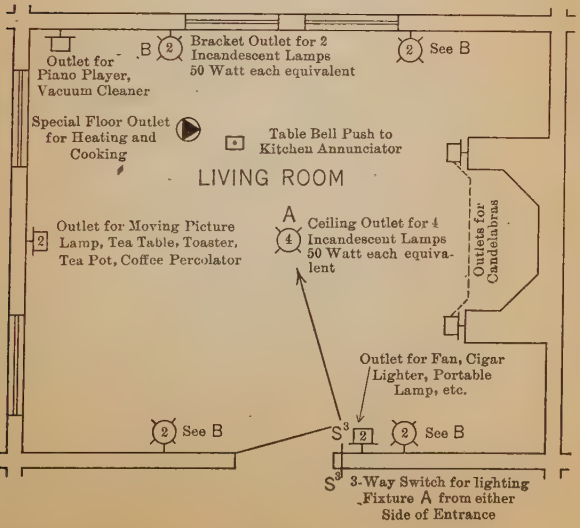
Art. 19b: A waterproof receptacle and plug should be located outside the main entrance, controlled by a switch in hall for step and walk canopy lighting.

A similar receptacle and plug may be placed high up on pillar or wall of porch for electric decorations.



These receptacles should be on a separate circuit from panel and controlled by a switch at porch door.

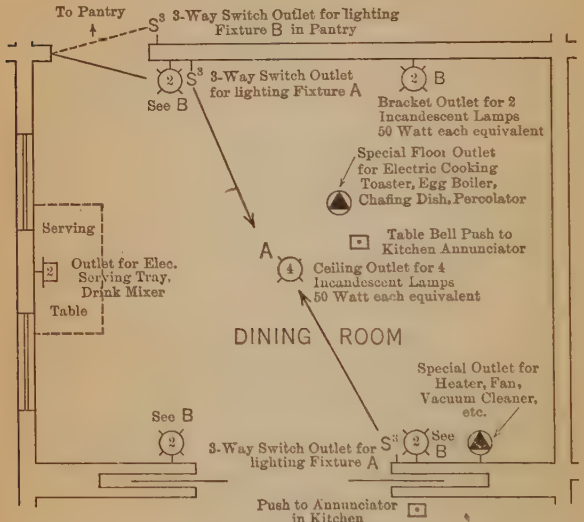

2 See B
Outlet for Cigar Lighter, Reading Lamp
B 2
Bracket Outlet for 2 Incandescent Lamps 50 Watt each equivalent
LIBRARY
A 4
Ceiling Outlet for 4 Incandescent Lamps 50 Watt each equivalent
Outlet for Vacuum Cleaner
Push to Kitchen Annunciator
See B
2
Public Telephone
S.P. Switch for lighting Fixture A
S1


Outlet for Piano Player, Vacuum Cleaner
B 2
Bracket Outlet for 2 Incandescent Lamps 50 Watt each equivalent
2 See B
Special Floor Outlet for Heating and Cooking
Table Bell Push to Kitchen Annunciator
LIVING ROOM
Outlet for Moving Picture Lamp, Tea Table, Toaster, Tea Pot, Coffee Percolator
2
A 4
Ceiling Outlet for 4 Incandescent Lamps 50 Watt each equivalent
Outlets for Candelabras
Outlet for Fan, Cigar Lighter, Portable Lamp, etc.
2 See B
S3
2
2 See B
S2
3-Way Switch for lighting Fixture A from either Side of Entrance

Porch Receptacles

Art. 19c: The living porch should have one or more flush wall receptacles placed in the side wall twelve or fifteen inches above the floor (to prevent water splashing on them). These receptacles are useful for reading lamp, chafing-dish, percolator, etc.

Bedroom porches may have a similar receptacle for reading light.


To Pantry
S3 3-Way Switch Outlet for lighting Fixture B in Pantry
2 S3 3-Way Switch Outlet for lighting Fixture A
See B
2 B
Bracket Outlet for 2 Incandescent Lamps 50 Watt each equivalent
Special Floor Outlet for Electric Cooking Toaster, Egg Boiler, Chafing Dish, Percolator
Serving
Table Bell Push to Kitchen Annunciator
A
Outlet for Elec. Serving Tray, Drink Mixer
4 Ceiling Outlet for 4 Incandescent Lamps 50 Watt each equivalent
Table
DINING ROOM
Special Outlet for Heater, Fan, Vacuum Cleaner, etc.
See B
2 3-Way Switch Outlet for lighting Fixture A
S3
2 See B
Push to Annunciator in Kitchen

Servants' or kitchen porches should have a receptacle pilot light and switch (see Art. 18), so that ironing may be done on the porch in hot weather. Such a receptacle should be on a separate circuit.

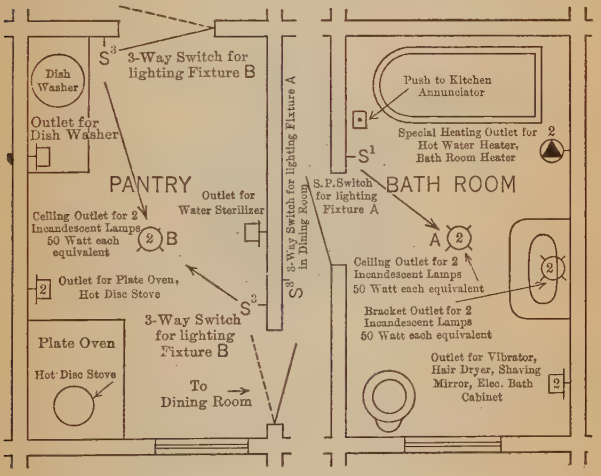
Mantel Receptacles

Art. 19d: Receptacles for mantel candles may be placed in the wall just above the shelf or, where the design will permit, in the shelf itself. These receptacles should be controlled by a switch at convenient location.

Bed Receptacles

Art. 19e: Two receptacles, one for reading lamp and one for heating pad or similar sick room appliance, should be placed at the side of each bed and connected to 110-volt lighting circuit. These may both be in the

same outlet box and covered with one plate. Alongside of this equipment, but not in contact with same, may be placed a bell receptacle with removable portable cord and hand "pear push" for bell call. This bell receptacle and plug must be of entirely different design from the two before mentioned so that by no possibility may the bell plug be attached to either of the other receptacles. These bell portables are connected to the same bell wires as the wall push button at door, so that either point rings the same bell or drop on the annunciator.


S3
3-Way Switch for lighting Fixture B
Dish Washer
Outlet for Dish Washer
PANTRY
Outlet for Water Sterilizer
Ceiling Outlet for 2 Incandescent Lamps 50 Watt each equivalent
2 B
Outlet for Plate Oven, Hot Disc Stove
2
S3
3-Way Switch for lighting Fixture B
Plate Oven
Hot Disc Stove
To Dining Room
S3 3-Way Switch for lighting Fixture A in Dining Room
Push to Kitchen Annunciator
Special Heating Outlet for Hot Water Heater, Bath Room Heater
2
S1
S.P.Switch for lighting Fixture A
BATH ROOM
A 2
Ceiling Outlet for 2 Incandescent Lamps 50 Watt each equivalent
2
Bracket Outlet for 2 Incandescent Lamps 50 Watt each equivalent
Outlet for Vibrator, Hair Dryer, Shaving Mirror, Elec. Bath Cabinet
2

Floor Receptacles

Art. 19f: Where receptacle outlets come in the floor they should be placed in specially designed floor boxes which have cone-shaped tops projecting above the floor to prevent water entering the box and to protect the wires. When these portables are not in use the cone top can be removed and a flush top substituted.

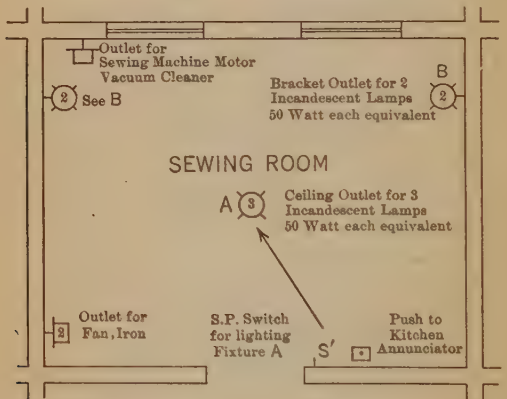
Stereopticon Receptacles

Art. 20: Stereopticon and moving picture machines are now made for home use. The receptacles for some have a larger capacity than those for lighting and are

usually placed at the end of the long living room or hall. They should be connected to 110-volt power and by means of two No. 8 wires.

Vacuum Cleaner Receptacles

Art. 21: Flush receptacles for portable vacuum cleaners should be so located that the thirty to fifty feet (30 to 50') of cord that goes with the cleaner will enable the operator to reach all parts of the house. They should be so arranged that the plugs are not interchangeable with those of other devices on the premises, as explained in Art. 19a. The momentary rush of current with many of the larger portable vacuum cleaners would blow the fuses of small circuits, and it is advisable to put these receptacles on a sepa-



rate No. 12 wire, and as but one point is used at a time, all the vacuum cleaner receptacles in the residence may be placed on the same circuit.

Dining Room Special Floor Outlet

Art. 22: There should be a receptacle and outlet box placed in the floor under the dining room table, a little off the center, so as to clear the center leg of table. This should be fitted with a removable plug connected to permanent table wiring (which is carried up the center leg of the table along the under framework and out on the crossbars, where the wiring should terminate in three 110-volt fused power receptacles. One of these may be used for electric chafing-

dish or egg boiler, one for electric toaster and one for electric coffee percolator. This enables the housewife to use the above appliances and disconnect and remove them as desired, without reaching to the floor and with practically no exposed connections, except the short ones over the edge of the table. The three receptacles under the edge of the table may, if desired, be mounted in a neat box to match the wood work (see Dining Room, page 216).

Two-Way Plugs

Art. 23: The accompanying cut shows a two-way plug for doubling the utility of the ordinary single lamp socket.

Two-Way Plug.

By its use the lamp may be retained for the necessary lighting, and a toaster, curling iron or other appliance may be attached.

Art. 24: Usually 10 or 15 watt lamps are sufficient for cellar lighting except in case of work bench or lathe, which should be brightly lighted by 25 watt or 40 watt lamps.

Outlets should be so located as to illuminate sinks, furnaces and any pumps or apparatus that need attention. Store rooms and vegetable rooms should be well lighted from ceiling with controlling switch at door. The wine room switch should preferably be placed outside the door, so that the room may be inspected through glass or grating of door without unlocking.

There should be at least one outlet in cellar controlled by pilot switch at the head of the stairs (see Art. 15e), and where there are few lights in the cellar it is sometimes advisable to put all on such a switch (see Cellar, page 212).

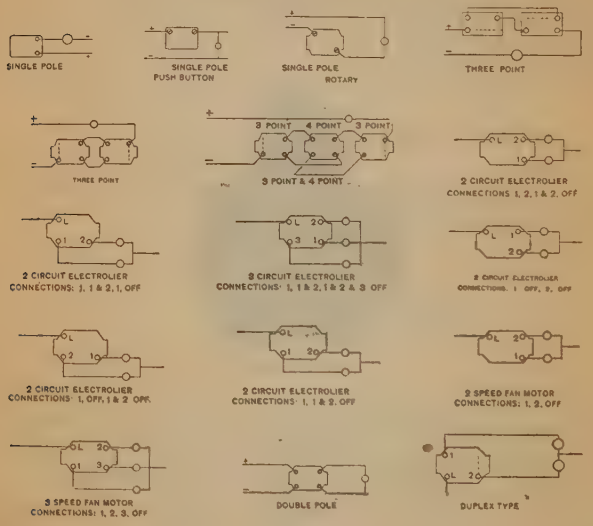
Porch Lighting

Art. 25: Porches are usually lighted from ceiling outlets controlled by a switch at porch door with receptacles for reading lamps, etc. (see Art. 19c; see Porch, page 209).

Room Lighting

Art. 26: In addition to mantel lights (see Art. 19d), side or ceiling lighting should be so designed as to

WIRING DIAGRAMS FOR FLUSH SWITCHES


SINGLE POLE
SINGLE POLE PUSH BUTTON
SINGLE POLE ROTARY
THREE POINT
THREE POINT
3 POINT
4 POINT
3 POINT
3 POINT & 4 POINT
2 CIRCUIT ELECTROLIER CONNECTIONS 1, 2, 1 & 2, OFF
2 CIRCUIT ELECTROLIER CONNECTIONS: 1, 1 & 2, 1, OFF
2 CIRCUIT ELECTROLIER CONNECTIONS: 1, 1 & 2, 1 & 2 & 3 OFF
2 CIRCUIT ELECTROLIER CONNECTIONS: 1, OFF, 2, OFF
2 CIRCUIT ELECTROLIER CONNECTIONS: 1, OFF, 1 & 2 OFF
2 CIRCUIT ELECTROLIER CONNECTIONS: 1, 1 & 2, OFF
2 SPEED FAN MOTOR CONNECTIONS: 1, 2, OFF
3 SPEED FAN MOTOR CONNECTIONS: 1, 2, 3, OFF
DOUBLE POLE
DUPLEX TYPE

properly illuminate all portions of a room (see pages 356-365) in such a manner as to allow the shifting of furniture from time to time without destroying the harmony of the interior. For this reason residence outlets should not be limited to the fewest possible required by the original furniture layout, but should be planned with a view to any rearrangement of furnishings. Outlets not needed with first scheme may be capped until required. For economy as well as for convenience, room lighting should be controlled by switches (see Art. 15a). Most rooms require one or more receptacles for portable lights (Art. 19). The

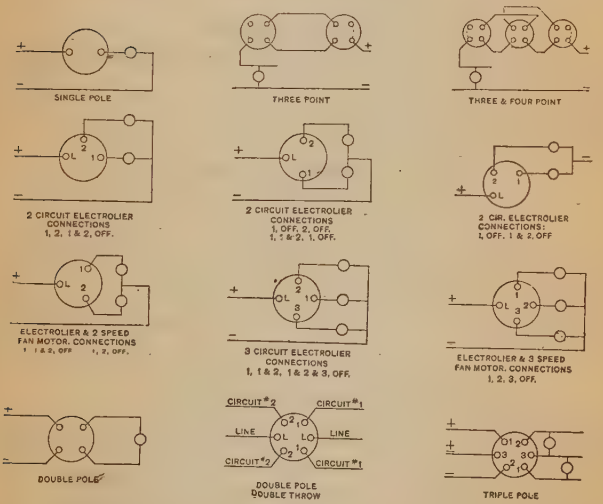
most modern practice places dependence upon a very few outlets for general lighting, and a generous supply of dead front receptacles set flush in baseboards.

A cigar lighter may be placed on the lighting circuit of den or living room. It uses very little current and does away with burnt matches. It needs no switch beyond the self-contained one.

The dining room table should be well lighted by ceiling domes or showers.

For bedrooms, in addition to the above room light-

WIRING DIAGRAMS FOR SURFACE SWITCHES


SINGLE POLE
THREE POINT
THREE & FOUR POINT
2 CIRCUIT ELECTROLIER CONNECTIONS 1, 2, 1 & 2, OFF.
2 CIRCUIT ELECTROLIER CONNECTIONS 1, OFF, 2, OFF, 1, 1 & 2, 1, OFF.
2 CIR. ELECTROLIER CONNECTIONS: 1, OFF, 1 & 2, OFF
ELECTROLIER & 2 SPEED FAN MOTOR. CONNECTIONS
3 CIRCUIT ELECTROLIER CONNECTIONS 1, 1 & 2, 1 & 2 & 3, OFF.
ELECTROLIER & 3 SPEED FAN MOTOR. CONNECTIONS 1, 2, 3, OFF.
DOUBLE POLE
CIRCUIT #2
CIRCUIT #1
LINE
LINE
CIRCUIT #2
CIRCUIT #1
DOUBLE POLE, DOUBLE THROW
TRIPLE POLE

ing, there should be a receptacle for desk lamp and also for a reading lamp at bed (see Art. 19e).

Hall Lighting

Art. 27: Halls require a soft general illumination, and the addition of portable table and vase lights is often advantageous. In addition to the wall switches for the regular lights, there should be up and down control between floors as mentioned in Art. 15b (see Hall, page 210).

Pantry Lighting

Art. 28: The pantry should be well lighted from a high center outlet so that contents of drawers and cupboards may easily be seen and this outlet should be controlled by a switch (see Pantry, page 213).

Kitchen Lighting

Art. 29: Kitchens are generally lighted from ceiling outlet controlled by switch at door. When, however, there are appliances around side wall at which the cook works, there would be a shadow if only the center fixtures were used, and side outlets should be added at such points and at the sink. The range-hood should have a light under same, as detailed in Art. 19a (see Kitchen, page 214).

Laundry Lighting

Art. 30: Laundries are usually finished in light color and need comparatively little general illumination from ceiling fixture controlled by a switch at door. A drop light should be provided at ironing table and a side light at laundry machine (see Laundry, page 214).

Bath Room Lighting

Art. 31: Most bath rooms may be well lighted by means of a two-light ceiling fixture or side outlets placed over the mirror, the fixtures projecting eight to 15 inches from wall and with two inverted lights in such position as to light top of head and each side of face, controlled by a switch at door. Bath room lights should never be so placed as to throw the shadow of anyone in the room on the window shade (see Bath Room, page 217).

Sewing Room Lighting

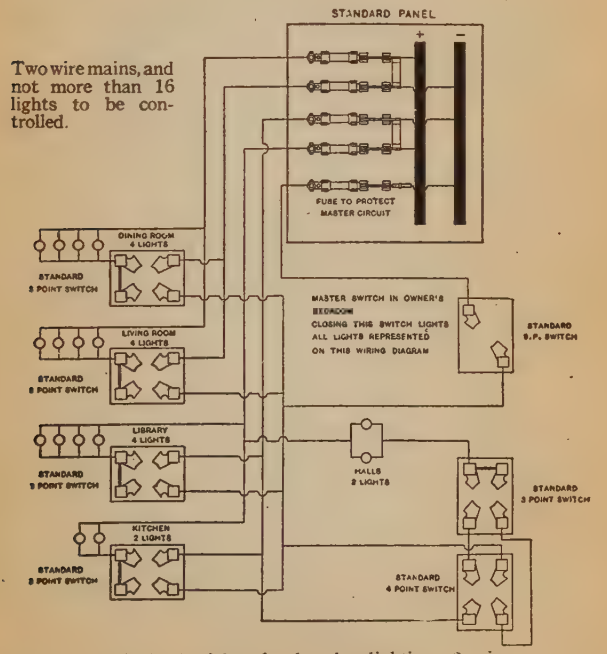
Art. 32: The general illumination of the sewing room may be from the ceiling with switch control. Side lights should be installed to brightly illuminate the sewing machine and cutting table and also the chair used for hand sewing. An outlet for electric pressing iron (see Art. 32) should be installed, and when the room is used in hot weather an electric fan adds to comfort. An eight-inch fan takes very little current—20 to 40 watts—and can be used on lamp Socket (see Sewing Room, page 218).

Closet Lighting

Art. 33: Closet lights are desirable unless room fixtures are so placed as to illuminate them. Especially is this true of storage and servants' closets, as it insures cleanliness. Closet lights should be controlled by wall or door switches (see Art. 15d; see Closet,

Play Room Lighting

Art. 34: The play room should be brightly lighted from the ceiling and controlled by a switch at door. This will prevent accidents to or from low side fixtures. The play room should also be wired for use as a bedroom with side lights and receptacles with outlets capped up for future use. If receptacles for toys are installed they should be of such a character as not to permit the toys being connected to other outlets.


STANDARD PANEL
+
−
Two wire mains, and not more than 16 lights to be controlled.
FUSE TO PROTECT MASTER CIRCUIT
DINING ROOM 4 LIGHTS
STANDARD 3 POINT SWITCH
LIVING ROOM 4 LIGHTS
STANDARD 3 POINT SWITCH
LIBRARY 4 LIGHTS
STANDARD 3 POINT SWITCH
KITCHEN 2 LIGHTS
STANDARD 3 POINT SWITCH
MASTER SWITCH IN OWNER'S BEDROOM
CLOSING THIS SWITCH LIGHTS ALL LIGHTS REPRESENTED ON THIS WIRING DIAGRAM
STANDARD D.P. SWITCH
HALLS 2 LIGHTS
STANDARD 3 POINT SWITCH
STANDARD 4 POINT SWITCH

Method of wiring for burglar lighting—2 wire

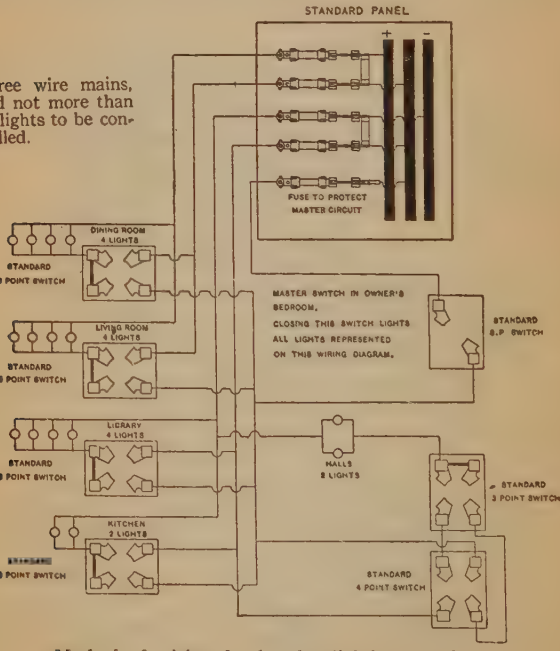
Servant Room Lighting

Art. 35: It pays to light servants' room from high ceiling lights designed for wide distribution of lighting and install switch at door for control of same. The

lights will be thus used more economically and the fixtures cannot be carelessly mishandled.

Workshop Lathe

Art. 36: Many owners like to provide a small workshop for their own use. A small wood turning lathe can be operated by a motor consuming about 200 watts. This lathe may be controlled by either a motor starter and switch, or by means of a switch only, as detailed in Art. 16 (see Cellar).


STANDARD PANEL
+
-
Three wire mains, and not more than 16 lights to be controlled.
FUSE TO PROTECT MASTER CIRCUIT
DINING ROOM 4 LIGHTS
STANDARD 3 POINT SWITCH
LIVING ROOM 4 LIGHTS
STANDARD 3 POINT SWITCH
MASTER SWITCH IN OWNER'S BEDROOM, CLOSING THIS SWITCH LIGHTS ALL LIGHTS REPRESENTED ON THIS WIRING DIAGRAM.
STANDARD 3-P SWITCH
LIBRARY 4 LIGHTS
STANDARD 3 POINT SWITCH
HALLS 2 LIGHTS
STANDARD 3 POINT SWITCH
KITCHEN 2 LIGHTS
3 POINT SWITCH
STANDARD 4 POINT SWITCH

Method of wiring for burglar lighting—3 wire.

House Pump

Art. 37: Where city water supply is not available and a well is used, a tank located on roof or attic can be filled by electric pump. The well pipe may be from 1½-inch diameter up, depending on the quantity of water needed. The motor may be controlled by hand or it may be automatic in action, as noted in Art. 17 (see Cellar, page 212).

If wiring is installed a double throw switch is usually placed in the basement or at the pump to permit hand operation so that tests may be made from time to time to see that everything is working satisfactorily. Water cocks may be placed around the lawn and water pumped through them directly for watering lawn, or for fire purposes without using up the water in the tank.

Refrigeration

Art. 38: Where ice is expensive or difficult to obtain, an ice box refrigerator electrically operated can be installed. These outfits require little attention, and in addition to keeping the box cool can be used to make a small amount of ice for table and sick room use.

Stereopticon

Art. 39: Stereopticon and moving picture machines are now made for residence use and are fast becoming an important part of the equipment of every home, especially where there are young people. Special receptacle should be provided as detailed in Art. 20.

Vacuum Cleaner

Art. 40: Portable vacuum cleaners are well known and much used. They should not be connected to the branch circuits feeding lights and small appliances (see Art. 9), but should be provided with a special circuit and their own outlets (see Art. 21). Sometimes a permanent machine is installed in the basement with pipes carried concealed in the walls and with convenient outlets on each floor to which hose may be attached. In such a case it is advisable to place near the motor an automatic distant control switch and carry one No. 14 wire branch circuit to flush receptacles placed close to each hose outlet. The plug is attached to the end of the hose with a small chain. The connections are such that when the hose is in use and the plug inserted into the receptacle, the cleaner will start up and when the hose is removed, thus pulling out the receptacle plug, the motor stops, preventing waste of current. The receptacles that are used for connection to portable machines and their circuit are not used in this case.

Plate Warmer

Art. 41: Plate warmers are very convenient and add much to the ease of service and success of dinners. They may be placed under dressers or pantry table and should be fitted with two or three heat switch and pilot light. When the first set of cold plates is placed

in warmer the switch is turned to high heat and left on for fifteen (15) minutes, when the lower heat is turned on and keeps the contents hot.

Dish Washer

Art. 42: Electric dish washers are of many makes, occupy small space, do their work quickly and well and need little attention. They may be controlled by a switch on machine or at wall (see Art. 16).

Metal Polisher

Art. 43: An electric silver and metal polisher consists of a one-quarter H. P. or one-half H. P. or larger motor. The ends of the motor shaft are arranged to receive various brushes, buffers, felt wheels and other fittings, all of which can be obtained with the outfit. By using such a machine the knives, forks, spoons and silverware may be kept in the best condition with a small expenditure of time and energy. There should be a switch and receptacle on wall, omitting pilot light (see Art. 18).

Ice Cream Freezer

Art. 44: An electric ice cream freezer insures the best and purest home product with but little trouble. The electric current expense is negligible. There should be a switch on machine with receptacle on wall or combined switch and receptacle on wall, omitting pilot light (see Art. 18).

Electric Cooking Range

Art. 45: Cooking by electricity is fast coming into more general use. The freedom from odors and escaping gas, the cleanliness and the application of heat only where needed, appeals strongly to the housekeeper and in many parts of our country such cooking may now be done as cheaply as with gas (see Art. 5).

An electric range for a family of six would occupy a floor space of about 22 inches by 28 inches. It is generally fitted with a number of separate switches for the various parts and utensils and should be on a separate three-wire feeder with three-pole main switch (see pages 95 to 98; see Kitchen, page 214).

Ironing Table

Art. 46: Laundry ironing tables may be purchased complete with swinging arms to take care of the cords and with two (2) irons for different classes of work, and so arranged with automatic stands that the iron when not in actual use takes only enough current to keep it hot (see Art. 23).

Clothes Washer and Wringer

Art. 47: The simplest type of electric clothes washer and wringer may be mounted on the tubs and removed when not in use. Other types have all parts mounted on one stand which may be on rollers to bring it to the tubs on wash days and remove it at other times. Such a machine for a family of six would occupy a floor space of about 28 inches by 32 inches, and the washing would be done better than by hand and with no danger of tearing laces and lingerie. It has a switch on the machine and should be connected to receptacle on wall (see Laundry, page 214).

Starch Cooker

Art. 48: A convenient and inexpensive appliance in the house laundry is an electrically heated pot for cooking starch. It should be connected to pilot switch and receptacle (see Art. 18).

Sewing Machine Motor

Art. 49: Every home should have the sewing machine fitted with a motor which may be very small in size and can be arranged to start and stop by pressing a contractor with the foot. It is very inexpensive to operate and saves many a doctor's bill where much sewing is done. The motor may be 110 volts and should be connected to a base receptacle.

Bath Room Heater

Art. 50: Heating rooms by electricity is not yet an economic fact, but for special cases where not in continual use, an electric heater is very convenient and not too expensive to operate. When taking a bath on a winter morning when the hot water is turned on an electric heater may also be turned on and by the time the tub is ready, the chill will be taken out of the air. For this purpose the heaters should have a capacity of four watts per cubic foot of room, although this is much greater than would be needed for continuous heating. These heaters should be on separate circuits and be supplied with combination pilot switches and receptacles (see Art. 18; see Bath Room, page 217).

Other Bath Room Appliances

Art. 51: Curling iron heaters may be mounted on the surface of the wall and are very small in size and consume current only when the iron is inserted into the heater. Hot water cups or stoves are much used, take up little space and should be connected to a combination pilot switch and receptacle (see Art. 18).

Instantaneous hot water electric faucets are now obtainable. They require about 1,500 watts, but are in

service for so short a time that the cost of operation is not high.

Entrance Bell Calls

Art. 52: The push button at the main entrance door should not ring on the annunciators, but should be a distinctive call, ringing a separate bell in kitchen or pantry. An extension bell should be placed in servant's room or corridor and a second extension may be placed in a sewing room that is much used. These extensions are controlled by small lever switches for cutting them off in time of sickness. The push button at rear entrance should ring a buzzer in the kitchen, but without the extensions.

Bell Annunciators

Art. 53: An annunciator should be placed in the kitchen with bell different in sound from adjacent bells and fitted with an indicating drop from each of the rooms, porches and baths in the house.

A second annunciator is often placed in servants' corridor and a third annunciator may be placed in the sewing room.

These two or three annunciators ring and indicate simultaneously for each call and are connected together by two or three wires more than the total number of calls or drops on each.

When a call is answered from any annunciator, a push at bottom of the annunciator resets all the annunciators, thus letting others know that the call is being attended to.

Wall Push Switch

Art. 54: Wall pushes are placed in the door trims of the various rooms, porches, bath, etc., and connected to the nearest annunciator. Bath room pushes are sometimes placed over tub rather than at the door.

Table Pushes

Art. 55: In some rooms, such as the living room, it is often desirable to have a table push on a flexible cord connected to a floor receptacle. These portable pushes are usually connected to the same wires as the wall push in such rooms. In case of the dining room, the table push rings a separate buzzer in the pantry while the wall push rings the annunciator.

Bed Pushes

Art. 56: Portable push buttons are frequently located at beds and they connect to the same wires as the wall pushes (see Art. 19e).

When the mistress of the house has a special maid, her bed portable push is usually connected to a buzzer in the maid's room.

Battery and Cabinet

Art. 57: The bell system may be operated from six to eight cells of dry battery, placed in a cabinet which may be located in the cellar. It is often well to use these batteries in duplicate with a throw-over switch so that while one set is being replaced or renewed the other set is in use (see Cellar, page 212).

Bell Ringing Transformer

Art. 58: Where alternating current is used for lighting, the bell system can be operated by a small bell ringing transformer which may be placed in the cellar and connected to one of the lighting circuits. These transformers may also be used for house intercommunicating telephone ringing, when the telephones are on metallic circuit. They cannot be used for telephone talking, which requires battery or direct current (see Cellar, page 212).

Where direct current is used, it is possible to employ in lieu of a transformer, one of the few approved types of D. C. bell ringers, which either operate on the potentiostat principle or charge a small storage battery through a vibrator.

Public Telephone

Art. 59: It is quite usual to put conduits in a residence for use of the Public Telephone Co. and thus keep their wires out of sight. A Public Telephone outlet may be placed in the kitchen or pantry with extensions to living room, owner's bedroom, and to still other points, if desired. A three-quarter-inch conduit is ample for the above equipment.

Turn-Down Lamps

Art. 60: A turn-down lamp which enables an incandescent lamp to be turned down to a dim light should be placed on one of the fixtures or portables in every bedroom, hall and bath room.

List of Current-Consuming Devices

Art. 61: Time and additional work, and consequent expense, to all concerned, may be saved if the house owner, at the start, is presented with a complete list of devices, for possible use in the various rooms of his house, that he may check off just what he may need.

Without such a list, which follows, many devices, later on, may suggest themselves, as needs demand them, and additional outlets may have to be provided,

and larger conductors may have to be installed to take care of them.

No one has ever complained of too many outlets—after they are once installed.

Halls.

Vacuum cleaner
Fan motor
Talking machine
Piano
Table lamp
Sewing machine
Turn-down lamp

Parlor or Reception Room.

Outlets
Table lamps
Vacuum cleaner
Fan motor
Piano
Talking machine

Dining Room

Toaster
Chafing dish
Coffee percolator
Tea kettle
Cigar lighter
Fan motor
Hot water heater
Radiant grill
Luminous radiator
Vacuum cleaner
Samovar

Bedroom or Boudoir

Luminous radiator
Vacuum cleaner
Curling iron
Water heater
Bed pan
Fan motor
Reading lamp at head of bed
Ozonator for sickness
Hair dryer

Kitchen

Irons
Washing machine
Stoves
Tea kettle
Disc stoves
Frying pans
Glue pot
Soldering iron
Radiant grill
Toaster
Vacuum cleaner
Fan motor
Coffee grinder
Meat chopper
Bread mixer
Egg beater
Silver polisher
Knife grinder

Sitting Room or Library

Table or desk lamp
Vacuum cleaner
Fan motor
Cigar lighter
Sewing machine
Small pressing iron
Luminous radiator

Laundry

Washing machine
Irons
Fan motor
Laundry machine
Vacuum cleaner

Nursery

Toys
Vacuum cleaner
Luminous radiator

Nursery (Continued

Vacuum cleaner of extra strength
Ozonator
Fan motor
Talking machine
Baby milk warmer

Bath Room

Luminous radiator
Vacuum cleaner
Shaving mug
Curling iron
Water heater
Hair dryer
Massage vibrator
Turn-down lamp
Hot water faucet

Girl's Room

Vacuum cleaner
Bed pad
Fan motor
Curling iron
Hair dryer

Garage

Several outlets for portables
Luminous radiator, if not heater

Glue pot
Soldering iron
Fire pumps
Small motor for tools
Portable drill
Grinding machine
Buffing machine
Charging batteries
Vacuum cleaner

Stables

Clippers
Milkers
Churns
Grind stones
Vacuum cleaner for currying

Offices

Vacuum cleaner
Luminous radiator
Cigar lighter
Hot water heater
Table or desk lamp
Fan motor

STANDARD SYMBOLS FOR WIRING PLANS

As adopted and recommended by The National Electrical Contractors Association of the United States and The American Institute of Architects

Ceiling Outlet; Electric only. Numeral in center indicates number of Standard 16 C. P. Incandescent Lamps.

4½ Ceiling Outlet; Combination. ½ indicates 4-16 C. P. Standard Incandescent Lamps and 2 Gas Burners.

If gas only.

Bracket Outlet; Electric only. Numeral in center indicates number of Standard 16 C. P. Incandescent Lamps.

4½ Bracket Outlet; Combination. ½ indicates 4-16 C. P. Standard Incandescent Lamps and 2 Gas Burners.

If gas only.

Wall or Baseboard Receptacle Outlet. Numeral in center indicates number of Standard 16 C. P. Incandescent Lamps.

Floor Outlet. Numeral in center indicates number of Standard 16 C. P. Incandescent Lamps.

Outlet for Outdoor Standard or Pedestal; Electric only. Numeral indicates number of Standard 16 C. P. Lamps.

Outlet for Outdoor Standard or Pedestal; Combination. 6/6 indicates 6-16 C. P. Standard Incandescent Lamps; 6 Gas Burners.

Drop Cord Outlet.

One Light Outlet, for Lamp Receptacle.

Arc Lamp Outlet.

Special Outlet, for Lighting, Heating and Power Current, as described in Specifications.

Ceiling Fan Outlet.

S. P. Switch Outlet.

D. P. Switch Outlet.

3-Way Switch Outlet.

4-Way Switch Outlet.

Automatic Door Switch Outlet.

Electrolier Switch Outlet.

Show as many Symbols as there are Switches. Or in case of a very large group of Switches, indicate number of Switches by a Roman numeral, thus: S^{1} XII, meaning 12 Single Pole Switches. Describe Type of Switch in Specifications, that is, Flush or Surface, Push Button or Snap.

Meter Outlet.

Distribution Panel.

Junction or Pull Box.

Motor Outlet; Numeral in center indicates Horse-Power.

Motor Control Outlet.

Transformer.

Main or Feeder run concealed under Floor.

Main or Feeder run concealed under Floor above.

Main or Feeder run exposed.

Branch Circuit run concealed under Floor.

Branch Circuit run concealed under Floor above.

Branch Circuit run exposed.

STANDARD SYMBOLS (Continued)

Pole Line.

Riser.

Telephone Outlet; Private Service.

Telephone Outlet; Public Service.

Bell Outlet.

Buzzer Outlet.

Push Button Outlet; Numeral indicates number of Pushes.

Annunciator; Numeral indicates number of Points.

Speaking Tube.

—© Watchman Clock Outlet.

—I Watchman Station Outlet.

—(TC) Master Time Clock Outlet.

—D Secondary Time Clock Outlet.

[T] Door Opener.

⊠ Special Outlet, for Signal Systems. as described in Specifications.

|||| Battery Outlet.

—·— Circuit for Clock, Telephone, Bell or other Service, run under Floor, concealed. Kind of Service wanted ascertained by Symbol to which line connects.

—··— Circuit for Clock, Telephone, Bell or other Service, run under Floor above, concealed. Kind of Service wanted ascertained by Symbol to which line connects.

NOTE—If other than Standard 25-watt Incandescent lamps are desired, specifications should describe capacity of lamp to be used. (See page 366.)

Standard Wiring Symbols

Art. 62: Owners, architects and contractors would save much time and misunderstanding by familiarizing themselves with, **and using,** the standard symbols as recommended by The National Electrical Contractors' Association and The American Institute of Architects, when indicating on plans just what is desired in the way of outlets, fixtures, receptacles, etc., etc., as given on pages 231-233.

GARAGE WIRING

A garage, from the standpoint of the underwriters' inspector, is considered as that building or portion of a building in which one or more self-propelled vehicles carrying volatile inflammable liquid for fuel or power are kept for use, sale, storage, rental, repair, exhibition or demonstration purposes; and all that portion of a building that is on or below the floor or floors on which such vehicles are kept which is not separated therefrom by tight unpierced fire walls and fire-resisting floors.

In addition to the general suggestions for inside wiring for low-potential currents given in the foregoing pages of this section the following additional suggestions should be adhered to in all garage wiring:

In garages with sufficient floor area to permit the storage of more than two vehicles, as above, all conductors except those required for pendant lamps or portable connections should be installed in approved metal conduit or approved armored cable, except that approved metal raceways may be used only in offices and show-rooms. Metal conduit, armored cable or metal raceways should be so installed that all outlet and junction boxes will be located at least four feet above the floor. In garages used for one or two vehicles, as above, conduit or armored cable construction is not necessary.

Flexible cord for pendant lights should be approved reinforced cord.

Flexible cords for portable lamps, motors or other apparatus should be approved cord designed for rough usage, preferably stage cable or packing house cord. The portable cord should carry the male end of an approved pin plug connector or equivalent, the female end being of such design or so hung that the connector will break apart readily at any position of the cable. The connector should be kept at least four feet above the floor.

Flexible cable for charging should be of approved theatre stage type, this cable carrying parts of approved connectors of at least fifty amperes capacity. The connectors should be of such design or so hung that at least one will break apart readily at any position of the cable. Current-carrying parts of connectors should be shielded to prevent accidental contact. The fixed, or wall connector, should be kept at least four feet above the floor, and if not located on switchboard or charging panel, should be protected against accidental contact.

Cut-outs, switches and receptacles should be placed at least four feet above the floor.

All portable lights should be equipped with approved keyless sockets of moulded composition or metal-sheathed porcelain type. These sockets should be equipped with handle, hook and substantial guard.

Switchboards and charging panels, at or upon which are mounted devices which in operation may produce a spark, should be located in a room or enclosure provided for the purpose unless all such spark producing devices are at least four feet above the floor or surrounded by vapor proof enclosures.

Motors or generators, not actually a part of a vehicle, if not located at least four feet above the floor should

be of the fully enclosed type. Motors located four feet or more above the floor, if not of the fully enclosed type, should be provided with wire screen of not less than No. 14 mesh over openings at commutator end.

THEATRE AND MOVING PICTURE HOUSES

All wiring and apparatus not specifically covered by the suggestions following should conform to the general recommendations given in the foregoing pages for all classes of low-potential wiring. The term "theatre" means a building, or that part of a building regularly or frequently used for dramatic, operatic, moving picture or other performances or shows or which has a stage for such performances used with scenery or other stage appliances.

Where current may be obtained from two separate street mains, two separate and distinct services should be installed, one service to be of sufficient capacity to supply current for the entire equipment of theatre, while the other service should be at least of sufficient capacity to supply current for all emergency lights. Where supply cannot be obtained from two separate sources the feed for emergency lights should be taken from a point on the street side of main service fuses. By "emergency lights" are meant exit lights and all lights in lobbies, stairways, corridors, and other portions of theatre to which the public have access, which are normally kept lighted during the performance.

Where the source of current is an isolated plant within same building an auxiliary service of at least sufficient capacity to supply all emergency lights should be installed from some outside source, or from a suitable storage battery within the premises.

All permanent construction on stage side of proscenium wall, except as hereinafter provided, should be approved conduit or armored cable.

Switchboards

All switchboards should be made of non-combustible, non-absorptive insulating material, and where accessible from stage level should be protected by a suitable guard-rail to prevent accidental contact with live parts on the board.

Dimmers should be dead when the switch controlling circuit of which dimmer forms a part is open.

Footlights should be wired in approved conduit or armored cable, each lamp receptacle being enclosed within an **approved** outlet box, or the lamp receptacles may be mounted in an iron or steel box, so constructed as to enclose all the wires and providing at least one-half inch separation between the metal of the box and receptacle terminals. Wires should be soldered to lugs of receptacles.

Footlights should be so wired that no set of lamps requiring more than 1,320 watts nor more than 32 receptacles should be dependent upon one cut-out.

Borders and proscenium sidelights should be constructed of steel of a thickness not less than No. 20 U. S. Sheet Metal gage, treated to prevent oxidation, be suitably stayed and supported, and so designed that flanges of reflectors will protect lamps.

They should be so wired that no set of lamps requiring more than 1,320 watts nor more than 32 receptacles shall be dependent upon one cut-out.

They should be wired in **approved** conduit or armored cable, each lamp receptacle enclosed within an approved outlet box, or the lamp receptacles may be mounted in an iron or steel box so constructed as to enclose all wires. Wires should be soldered to lugs of receptacles.

Suitable guards should be provided to prevent scenery or other combustible material coming in contact with lamps.

Cables for borders should be of **approved** type and suitably supported; conduit construction should be used from switchboard to point where cables must be flexible to permit of the raising and lowering of border.

For the wiring of the border proper, wire with **approved** slow-burning insulation should be used (see page 125).

Borders should be suitably suspended, and if a wire rope is used same should be insulated by at least one strain insulator inserted at the border.

Stage and gallery pockets should always be of **approved** type, insulated from ground and controlled from switchboard, each receptacle to be of not less than 35 ampere rating for arc lamps nor 15 amperes for incandescent lamps, and each receptacle should be wired to its full capacity. Arc pockets should be wired with wire not smaller than No. 6 B. & S. gage and incandescent pockets with not less than No. 12 B. & S. gage.

Plugs for arcs and incandescent pockets should never be interchangeable.

Where lamps are installed in scene docks they should be so located and installed that they will not be liable to mechanical injury.

Curtain motors should be of enclosed type and installed so as to conform to the general suggestions given in the section on Motors, page 326.

In cases where dampers are released by an electric device, the electric circuit operating same should be normally closed.

Magnet operating damper should be wound to take full voltage of circuit by which it is supplied, using no resistance device, and should not heat more than normal for apparatus of similar construction. It should be located in loft above scenery, and be installed in a suitable iron box with a tight, self-closing door.

Such dampers should be controlled by at least two standard single pole switches mounted within **approved** iron boxes provided with self-closing doors without lock or latch, and located, one at the electrician's station and others as designated.

Dressing rooms should be wired in **approved** conduit or armored cable. All pendant lights should be equipped with **approved** reinforced cord, armored cable, or steel armored flexible cord.

All lamps should be provided with **approved** guards which are sealed or locked in place.

All portable equipment, such as arc lamps used for stage effects, should conform to the following suggestions:

They should be constructed entirely of metal of a thickness not less than No. 20 U. S. Sheet Metal gage except where use of **approved** insulating material is necessary and should be substantially constructed and so designed as to provide for proper ventilation, and to prevent sparks being emitted from lamps when same are in operation, and mica should be used for frame insulation.

Front opening should be provided with a self-closing hinged door frame, in which wire gauze or glass should be inserted, except in the case of lens lamps, where the front may be stationary, and a solid door provided on back or side.

They should be so constructed that neither carbons nor live parts will be brought into contact with metal of hood during operation, and arc lamp frames and

standards should be so installed and protected as to prevent the liability of their being grounded.

The switch on standard should be so constructed that accidental contact with any live portion of same will be impossible.

All stranded connections in lamp and at switch and rheostat should be provided with approved lugs.

Rheostats should be plainly marked with their rated capacity in volts and amperes, and, if mounted on standard, should be raised to a height of at least three inches above floor. Resistance should be enclosed in a substantial and properly ventilated metal case which affords a clearance of at least one inch between case and resistance element.

A competent operator should be in charge of each arc lamp, except that one operator may have charge of two lamps when they are not more than ten feet apart, and are so located that he can properly watch and care for both lamps.

Bunches should be substantially constructed of metal and should not contain any exposed wiring.

The cable feeding bunches should be tubed in an approved manner where passing through the metal, and should be properly secured to prevent any mechanical strain from coming on the connection.

Strips should be constructed of steel of a thickness not less than No. 20 U. S. Sheet Metal gage, treated to prevent oxidation, and suitably stayed and supported and so designed that flanges will protect lamps.

Cable should be tubed in a suitable manner where passing through the metal, and should be properly secured to prevent serious mechanical strain from coming on the connections.

Strips should be wired in approved conduit or armored cable, each lamp receptacle being enclosed within an approved outlet box, or the lamp receptacles may be mounted in an iron or steel box, metal to be of a thickness not less than No. 20 U. S. Sheet Metal gage, so constructed as to enclose all wires. Wires should be soldered to lugs of receptacles.

Portable plugging boxes should be constructed so that no current carrying part will be exposed, and each receptacle should be protected by approved fuses mounted on slate or marble bases and enclosed in a fireproof cabinet equipped with self-closing doors. Each receptacle should be constructed to carry thirty amperes without undue heating, and the bus-bars should have a carrying capacity equivalent to the cur-

rent required for the total number of receptacles, and approved lugs should be provided for the connection of the master cable.

Pin plug connectors should be of an approved type, so installed that the "female" part of plug will be on live end of cable, and should be so constructed that tension on the cable will not cause serious mechanical strain on the connections.

Portable flexible conductors used from receptacles to arc lamps, bunches and other portable equipments should be approved stage cable except that for the purpose of feeding a stand lamp under conditions where conductors are not liable to severe mechanical injury, an approved reinforced cord may be used, provided cut-out designed to protect same is not fused over ten amperes capacity.

Lights on scenery, such as brackets, should be wired entirely on the inside; fixture stem should come through to the back of the scenery and end of stem be properly bushed and fixtures be securely fastened in position.

Where lamps are used in lanterns or similar devices approved guards should be employed.

Where devices are used for producing special effects such as lightning, waterfalls, etc., the apparatus should be so constructed and located that flames, sparks, etc., resulting from the operation cannot come in contact with combustible material.

All auditorium wiring should be installed in approved conduit, metal raceways or armored cable. Where receptacles are used they should be enclosed in approved boxes.

Exit lights should not have more than one set of fuses between same and service fuses.

Exit lights and all lights in halls, corridors or any other part of the building used by audience, except the general auditorium lighting, should be fed independently of the stage lighting, and should be controlled only from the lobby or other convenient place in front of the house.

All fuses should be enclosed in approved cabinets.

Wiring for Organs

The current required for electrically operated organs should be from either a self-excited generator rated at not over fifteen volts or from a primary battery.

The generator should either be permanently and effectively insulated both from ground and from the motor driving it or both generator and motor should have their base frames permanently and effectively grounded.

All wiring should be cabled except common return wires and wires inside the organ proper, the organ sections and the organ console.

The separate conductors of the cable should not be smaller than No. 26 B. & S. gage and have either rubber, cotton or silk insulation. The cotton or silk may be saturated with paraffine if desired.

The separate conductors may be either bunched or cabled and should be covered by one or more braided outer coverings. A tape may be substituted for an inner braid. The outside covering of cables not run in conduit should either be flameproof or covered with a closely wound fireproof tape.

The common return wire or wires should not be contained in the cable, but should be run in contact with it or placed under an additional covering enclosing both cable and return wires.

The insulation of return wires should be either rubber or slow-burning and not smaller than No. 14 B. & S. gage.

All wiring and devices within the organ or any of its parts should be neatly disposed and securely fastened.

It is not found to be either necessary or feasible in organ structures to require the use of non-combustible, non-absorptive insulating material for the supports or enclosures of current carrying parts.

Cables between parts of the organ and between the console and the organ should be installed in a workmanlike manner, be securely fastened in position and kept from contact with other wires. Conduit may be used but is not necessary.

Circuits should be so subdivided and protected at the generator by approved enclosed fuses of not over thirty amperes capacity that every wire will be protected by one or more such fuses.

No other fuses in the organ circuits will be necessary.

MARINE WIRING AND CONSTRUCTION

All wiring, apparatus and construction not specifically covered by the following sugestions should conform to the general suggestions given in the preceding pages of this section on Inside Wiring.

Generators should be located in a dry place and provided with protecting hand rails.

They should be provided with a name plate giving the maker's name, the capacity in volts, amperes and kilowatts, the normal speed in revolutions per minute, and whether shunt, series or compound.

Generators or storage batteries employed for auxiliary (emergency) lighting or power should be located as far above the load water line as practicable.

Wires should, except around generators, at switchboards and in wire tunnels, be enclosed in **approved** metal raceways or metal conduits, unless covered with **approved** metal armor or metallic braid.

All conductors larger than No. 12 B. & S. gage should be stranded. Except in fixture wiring no single conductor smaller than No. 14 B. & S. gage should be employed.

Except at fixtures, conductors should not be spliced, unless under special permission in writing given in advance.

Except at fixtures, and as suggested in the preceding paragraph, splices and taps should be made by means of **approved** connection blocks enclosed in **approved** fittings. These fittings should be located in readily accessible places and should not be located in bunkers.

All wires should be led through metallic stuffing tubes where passing through water-tight bulkheads and through all decks, deck tubes being extended to a height of eighteen inches above the surface of the deck.

They should not be drawn in until all mechanical work on the vessel has been completed.

Pull boxes should be installed at sufficient intervals to permit of the drawing in of conductors without undue strain. These pull boxes should be provided with gasketed water-tight covers, and the length of the opening in the box should be at least ten times the diameter of the largest conductor contained therein.

When enclosed in metal raceways, flexible metal conduit, metal armor or metallic braid, all wires should be provided with additional mechanical protection

where passing through coal bunkers and where otherwise exposed to severe mechanical injury.

Where metallic braid cable passes through beams or non-water-tight bulkheads it should be protected from abrasion. All sharp bends in such cable should be avoided.

Portable Conductors. They should be made of two or more stranded conductors, each having a carrying capacity equivalent to No. 14 B. & S. gage or larger, and each provided with an approved insulation and covering.

Bell or Other Signalling Wires. They should be of not less than No. 16 B. & S. gage and should not be run in the same conduit, raceway or armor with light or power wires.

Where radio systems are employed, all permanent wiring in the radio room and above the top metal deck should be magnetically shielded. Any protection placed around antennae leads to prevent ready access to same should be of metal, permanently and effectually grounded.

It is strongly recommended that all metal work above the top metal deck be permanently and effectually grounded.

Switchboards. They should be made of approved non-combustible, non-absorptive insulating material, kept free from moisture and so located as to be accessible from all sides.

They should have a main switch, automatic cut-out and ammeter for each generator and at least one voltmeter and one ground detector.

Each circuit leading from the board should be protected by a cut-out and controlled by a switch.

Cut-Outs and Switches. They should, except on switchboards and in living spaces, be enclosed in moisture-proof cases and be arranged to break all poles of the circuit and not be located in bunkers or other inaccessible places.

They should be so arranged that each freight compartment may be separately protected and controlled and be enclosed in metal cabinets when located elsewhere than on switchboards.

Except for motors, searchlights and diving lamps, they should be so placed that no group of lamps or other current-consuming devices requiring more than 660 watts should be dependent upon one cut-out.

Removable Fittings. In vessels having any space allotted alternately to passengers and cargo, the fix-

tures and wiring in such space should be so designed as to be removable and the points of disconnection so arranged that they can be properly insulated and covered up. Main fuses and switches should not be located within these spaces.

Signal Lights. They should be provided with approved telltale board, located preferably in pilot house, which will immediately indicate a burned-out lamp. Each side of all signal circuits should be carried through the telltale board and fused at this point.

Signal circuits should never supply other than pilot house and signal lights.

Motors. Every motor should be provided with a name plate giving the maker's name, the capacity in volts, amperes and kilowatts, and the normal speed in revolutions per minute.

Insulation Resistance. The wiring in any vessel should have a resistance between conductors and between all conductors and the ground (not including attachments, sockets, receptacles, etc.) not less than that given in the following table:

Up to	5	amperes	4,000,000	ohms
"	10	"	2,000,000	"
"	25	"	800,000	"
"	50	"	400,000	"
"	100	"	200,000	"
"	200	"	100,000	"
"	400	"	50,000	"
"	800	"	25,000	"
"	1,600	"	12,500	"

The test should be made with all cut-outs and safety devices in place. If the lamp sockets, receptacles, electroliers, etc., are also connected, only one-half of the resistances specified in the table will be necessary.

It is strongly urged that a complete test of the insulation of the entire electrical equipment be made at least once a year.

Approval of Apparatus and Supplies. Every article or fitting intended for use in electrical wiring or construction or in connection therewith should, before being manufactured or placed upon the market, be submitted to the Underwriters' Laboratories, 207 East Ohio Street, Chicago, for examination and report. Branch offices are located in thirty-two other cities of the United States and Canada. The New York office, at 25 City Hall Place, is equipped for the conduct of

examinations and tests of all electrical devices under the same conditions as those afforded at the principal office and testing station in Chicago.

The amounts of the fees are in proportion to the nature and extent of the work required in examinations and tests. When any article or device is approved and found safe and suitable for the use intended it is placed in the List of Inspected Electrical Appliances, issued semi-annually by the Underwriters' Laboratories, for use in accordance with the rules and requirements of the National Electrical Code, which govern the suggestions given in this book. This list is supplemented by index cards mailed to all inspection departments who subscribe to the service, so that each department has immediate knowledge of the approval of a device, and need not wait for the semi-annual edition of the booklet.

When buying electrical supplies of any description make sure that they have been approved, or that their use will be permitted. If there is any question about it make your supply dealer or the manufacturer give you a guarantee that they will be approved by the Fire Underwriters' Inspector if installed in accordance with the rules and requirements of the National Electrical Code.

Electrical Inspection. The principal points regarding the safe installation of generators, storage batteries, motors, heaters and outside and inside wiring, as required by the Fire Underwriters, are briefly set forth in this book, which has been compiled simply for reference, and intended to settle most of the doubtful questions which might arise in the mind of the engineer, architect or contractor as to just what will be considered safe by insurance inspectors. There may arise questions which cannot be settled by reference to the suggestions herein contained, and, therefore, a great deal has to be left to the judgment of the constructing engineer, architect, contractor and inspector. In every such case the Inspection Department having jurisdiction should be consulted with perfect assurance that nothing unreasonable will ever be demanded in the way of special construction.

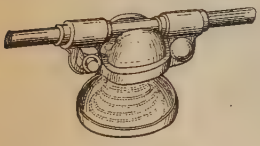
Every piece of wiring or electrical construction work, whether open or concealed, should be inspected, and notice therefore should always be sent by the contractor or engineer to the board having jurisdiction immediately upon completion of any work. Negligence in this matter has frequently caused floors to be torn up when doubtful work has been suspected.

OUTSIDE WIRING AND CONSTRUCTION

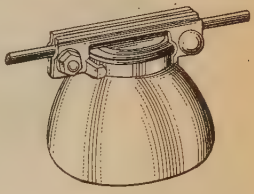
Service Wires (those leading from the outside support on the building, through the wall and to the main cut-out and switch) should be "Rubber Covered," as described on page 117, under that heading.

Line Wires, other than service wires, may have an approved "weatherproof" covering (see page 125) if kept free from awnings, signs and shutters.

Bare Wires may be used through uninhabited and isolated territories free from all other wires, as in such places wire covering would be of little use, as it is not relied on for pole insulation.



For Insulated Wires.



For Bare Wire or Cable.

Insulator Clamps.

Tie Wires should have an insulation equal to that of the conductors they confine, within city limits, or some permanent insulated clamp that will not injure the insulation of the wires.

Space Between Wires for outside work (see diagrams, pages 280 to 293), whether for high or low tension, should be at least one foot, and care should be exercised to prevent any possibility of a cross connection by water. Wires should never come in contact with anything except their insulators. They may, however, be run in the form of multiple conductor cable or in conduit. When multiple conductor cables are used they should be secured to strain insulators spaced not less than one foot from any adjacent wood work and in turn secured to petticoat or strain insulators by strain wires.

When conduit is used the conduit system should be thoroughly waterproof or the conductors therein lead sheathed.

Standard Fastenings For Standard Wiring

See pages 48 and 65 of this issue

TYPE A

"CLARK" PRODUCTS

Insulator Clamps—A standard design for your special condition.

Line Crossing Clamps—Approved by Railroads, Telephone and Central Stations for High Tension Crossings.

Seamless Copper Splicing Sleeves, *Single Tube*, make practically a welded joint and without the use of solder. Used on all important transmission lines.

Descriptive Bulletins on request.

The Clark Electric and Manufacturing Company

149 Broadway New York

Roof Structures. If it should become necessary to run wires over a building, the wires should be supported on strongly made racks which will raise them from 8 to 12 feet above flat roofs, as shown on page 53, or at least one foot above the ridge of pitched roofs.

Guard Arms. Whenever sharp corners are turned, each cross arm should be provided with a dead insulated guard arm, or guard iron, to prevent the wires from dropping down and creating trouble, should their insulating support give way (see Fig. 2, page 248).

Petticoat Insulators (see illustrations on page 250) should be used exclusively for all outside work, and especially on cross arms, racks, roof structures and service blocks. Porcelain knobs, cleats or rubber hooks should never be used for this heavy outside work. In fact, rubber hooks are not now approved for any form of electric light or power work. Wires on exterior walls of buildings should be supported at least every fifteen feet, and this distance should be even shorter if the wires are liable to be disturbed.

Splicing of two pieces of wire or cable should be so done as to be mechanically and electrically secure without solder. They should then be soldered (see Soldering, page 411), unless made with some form of **approved** splicing device (see illustration, page 6). This ruling applies to joints and splices in all classes of wiring. All joints, whether soldered or made with an approved splicing device, should be covered with an insulation equal to that of the conductors.

Tree Wiring. Whenever a line passes through the branches of trees, it should be properly supported by insulators to prevent the chafing of the wire insulation and the grounding of the circuit.

The tree insulators shown on page 250 have proved themselves to be practical and permanent insulators, allowing the free swaying of limbs without chafing the insulation of the wires.

Service Blocks which are attached to buildings should have at least two coats of waterproof paint to prevent the absorption of moisture.

Size of Wire. To find the required size of wire in circular mils for any alternating current system, to carry any required current any distance at any voltage and with any required loss, use the formulas and examples on pages 6 to 14, and for direct current the formulas on pages 308 to 309. When possible, however,

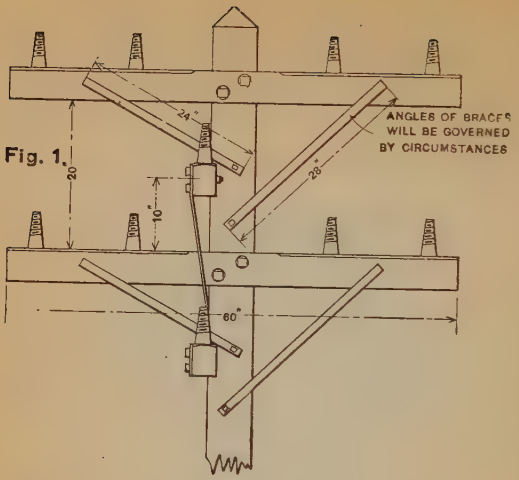


Fig. 1.

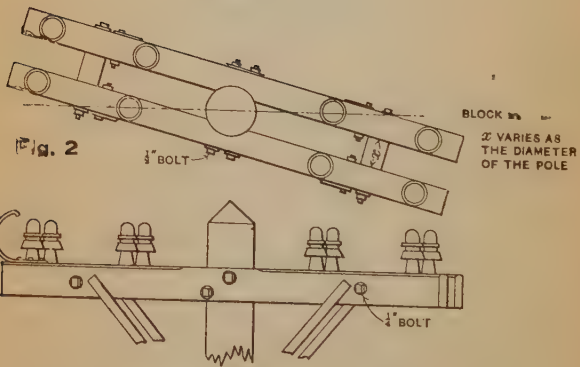
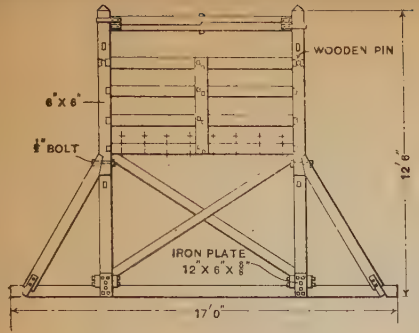


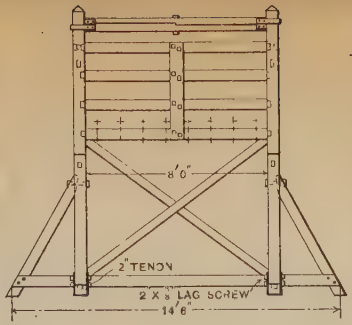
Fig. 2

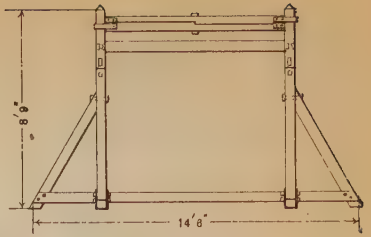
CONSTRUCTION WORK

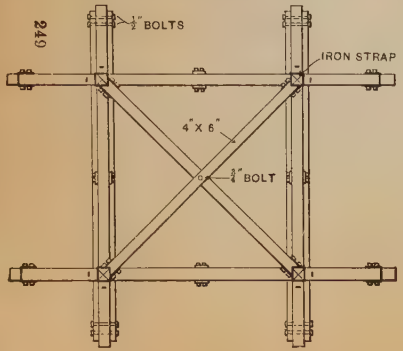
Position of Cross-Arms when Turning Corners

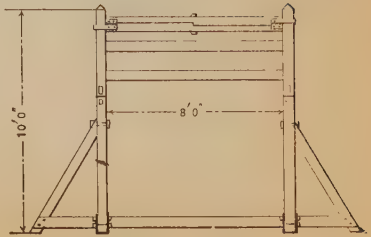
When running a heavy line where it is necessary to use two cross arms fastened as shown in Fig. 2. If lines are not heavy, only one cross arm will be necessary. In case lines cross the street diagonally, the arms where the wires leave and those to which they run are both set at an angle. When turning an abrupt corner, only one arm is turned. The above cannot be used where feeders tap into double branches. In such cases the method as given in Fig. 1 is used.





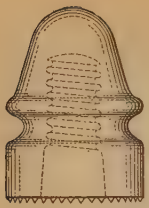






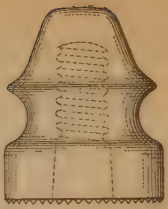
CONSTRUCTION WORK

Structures for Flat Roofs



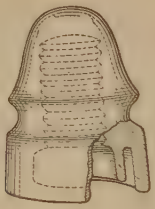
3000 Volts

10000 Volts



5000 Volts

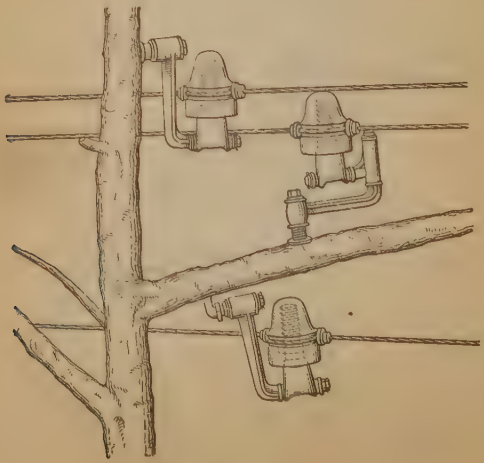
6000 Volts



4000 Volts

15000 Volts

For higher voltages, see page 161.



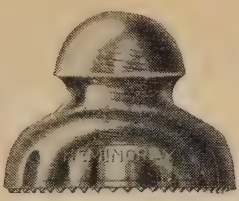
Tree Insulators

TRADE MARK

STANDARD HEMINGRAY INSULATORS

REGISTERED.

No. 19, Deep Groove Double Petticoat



No. 71, High Voltage Triple Petticoat

No. 62 Cable Double Petticoat

For years the name "Hemingray" has been synonymous, not only with "glass insulators," but with "good glass insulators." The Hemingray insulators, have been and are *good insulators,* because they have been and are of good design and material subjected to proper processes of manufacturing, including especially perfect annealing. In a glass insulator, "good design" means more than proper lines electrically,—it means a design which so distributes the material that good annealing is possible. Given such a design and a proper proportioning of materials (including *not too much cullet*), it is possible to obtain, and the Hemingray Glass Company does produce a completed insulator, every part of which is perfectly annealed.

Thorough annealing is of supreme importance in a glass insulator, and faults which have been found against glass as a material for line insulators have been due to the past practice of some other manufacturers who not only have used improper annealing methods, or material which was practically incapable of being properly annealed, but also have accepted for manufacture certain designs of insultors which so distributed the material as to make proper annealing practically impossible, no matter what materials or methods were used. The HEMINGRAY GLASS COMPANY has followed as one of its first principles the practice of not accepting for manufacture any design which their sixty-five years of experience would indicate could not be properly and perfectly annealed. This is the prime reason for the uniform success of the Hemingray insulator; the reason for its superior mechanical quality of strength and capabilities to withstand the shocks of sudden blows or rapid and extreme temperature changes; the reason for its remarkable electrical qualities as a high voltage insulator.

Insulators for Telephone, Telegraph, Light and Power

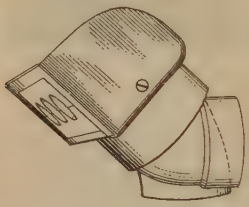
HEMINGRAY GLASS CO.

Established 1848 ***Incorporated 1870***

MUNCIE, INDIANA

refer to tables and examples on pages 6-13, as they will be found much simpler when within their limitations.

Service Wires. Where service wires enter a building they should have drip loops outside and the holes through which the conductors pass should be bushed with non-combustible, non-absorptive insulating tubes, such as glass or porcelain, slanting upward toward the inside.



An Approved Service Head for Service or Entrance Wires. It may be used in either a horizontal or vertical position.

Where metal conduit (see page 64) is used the conduit—and this method is permitted on low-potential systems, which means 550 volts or less—should be curved downward at its outer end and carefully sealed; or a much better method is to use an approved service-head to prevent the entrance of moisture.

The inner end should extend to the service cut-out. If a cabinet is used the conduit should be properly carried within the cabinet.

Metal conduits containing service wires should be grounded in accordance with the recommendations given in the section on grounding, pages 101 to 108, unless the conduit is insulated from the ground and from the metal conduit, metal raceway or armored cable system within the building and from all metal work on or in the building and contains no conductors of circuits exceeding 150 volts to ground.

The service conduit may be insulated as above when containing circuits exceeding 150 volts to ground if isolated or guarded.

If conduit, couplings or fittings having protective coating of non-conducting material, such as enamel,

are used, such coating should be thoroughly removed from threads of both coupling and conduit, and from surfaces of such fittings where the conduit or ground clamp is secured in order to obtain the requisite good connection. Grounded pipes should be cleaned of rust, scale, etc., at place at attachment of ground clamp.

Connections to grounded pipes and to conduit should be exposed to view or accessible, and should be made by means of **approved** ground clamps.

Ground wires for metal conduit, metal raceway and armored cable systems need not be larger than No. 10 B. & S. gage when the largest wire in the system is not greater than No. 0 B. & S. gage.

The ground wire for the service conduit, however, should not be smaller than No. 6 B. & S. gage. Such ground wires should be protected from mechanical injury.

Grounding Direct-Current Distributing Systems. Three-wire direct-current systems (except circuits entirely unexposed to leakage or induction through overhead construction from overhead circuits above 550 volts) should be grounded as provided for on pages 101 to 108.

Two-wire direct-current systems may be grounded, and if grounded should comply with the requirements given on pages 101-109.

Grounding Alternating-Current Distribution Systems. All secondary distribution systems (except circuits entirely unexposed to leakage or induction through overhead construction from overhead circuits above 550 volts or through transformer or other devices) should be grounded, provided the maximum difference of potential between the grounded point and any other point in the circuit does not exceed 150 volts, and may be grounded when the potential exceeds 150 volts (see pages 101 to 108).

Transformers should not be placed inside of any building excepting central stations or sub-stations, and should not be attached to the outside walls of buildings when the potential exceeds 550 volts, unless separated therefrom by substantial supports. In cases where it is impossible to exclude the transformer and primary wiring from entering the building, the transformer should be located as near as possible to the point where the primary wires enter the building and placed in a ventilated vault, constructed of or lined with fire-resisting material containing nothing but the transformers. It is, of course, the safest practice to place all

transformers on poles away from the building that is to be wired. Special permission should always be secured, in writing, when it is desired to install transformers on or inside of buildings other than central or sub-stations (see pages 91 and 190).

Selection and Care of Transformers

The following suggestions regarding the selection of transformers for power service should be kept in mind, and if followed good results will be obtained.

1. For induction motors, whether single, two or three-phase, in sizes of 5 H. P. or less, transformer equipment should be based on 1,500 watts per H. P. of motor.

This is because of the large starting current required and the low power factor of these motors, the apparent current consumption, as read in amperes on the secondary of the transformer, being very much greater than the actual consumption as indicated by the watt meter.

2. For induction motors, single, two or three-phase, larger than 5 H. P., where used only ten to twelve hours per day, transformer equipment should be based on 1,000 watts per H. P. of motor. This is a well-established rule and one that is safe.

3. For induction motors, single, two or three-phase, larger than 5 H. P., where required for service twenty-four hours per day, transformer equipment should be based on 1,200 watts per H. P. of motor.

Where any lighting is required from power transformers additional transformer capacity should be provided to take care of it.

If the above is borne in mind in selecting sizes for power, and lighting transformers are provided that have the rated capacity for the work required of them, no trouble should be expected.

For mixed lighting and power work or for lighting only, in cities and towns, it is advisable to employ as large units as can be used to advantage, covering considerable territory with several large units on common secondaries rather than a great number of small units on individual secondaries, for three reasons: First, less first cost of transformers—if one 500-light transformer costs $216, twenty-five ten-light will cost $387; second, better results as to regulation, everybody's light will burn at the same voltage; and, third, economy in operation. The core loss on one 500-light transformer will be about 200 watts, while on twenty-five ten-light transformer, or the same capacity, will be about 550 watts.

Fully Guaranteed for ONE YEAR

PEERLESS Transformers

are fully *guaranteed* but our idea of a *square deal* is a lot bigger than any formal guarantee. When you buy a transformer from *us* it's going to give you the kind of service you have a right to expect and we'll see that it *does*. THAT'S ALL.

Enterprise Electric Co.

Warren, Ohio

Transformers are a very important part of the equipment of a plant, and are apt in a great many cases to be very much neglected. Usually a transformer is installed, and so long as no trouble develops that interferes with the service, no attention is paid to it. The old familiar saying, "A stitch in time saves nine," applies very nicely, as will be explained.

To begin with, it is assumed that the character of the work required of the transformer has been taken into consideration in its purchase, so that it is of proper capacity. Whether it is installed on a pole, in a substation, or subway, it should be carefully installed, all joints being soldered or otherwise properly made up (unless familiar with connections, diagram as furnished by the manufacturer should be carefully consulted to avoid mistakes).

If it is an oil transformer it is important that it be filled with oil, not only on installing, but for three or four days; the first filling will be absorbed by the coils, so that it should be refilled two or three times until the oil remains at a permanent level. Evaporation will lower this level very slowly, but all transformers should be examined and refilled, if necessary, at least once each year, preferably in the early spring, before electrical storms become prevalent.

Primary fuse-boxes of approved type should be used with every transformer, and no transformer should be fused heavier than 50 per cent. above its capacity; if that don't hold look for trouble, as it is certain that something is wrong. **Never substitute copper wire for fuse wire.**

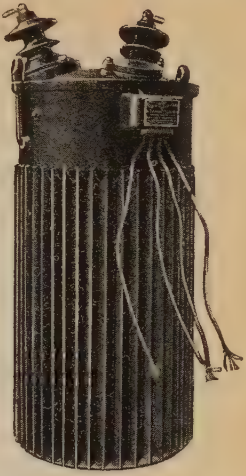
Lightning arresters should be provided on all lines liberally, to take care of static discharges in case of storms, and with plenty of these, transformers properly filled with oil, and not overloaded, very little trouble should be experienced.

Well designed transformers, when operated at their rated capacity, should not exceed 40° C. in temperature rise; when transformers go beyond this harm is being done the transformer that cannot be repaired, the core loss will increase, due to the action of heat on the steel in the core, that can only be remedied by reannealing, an expensive process, which is out of the question; but so long as the temperature remains between 30° C. and 40° C. there will be so little increase in core loss, due to aging, that it need not be considered.

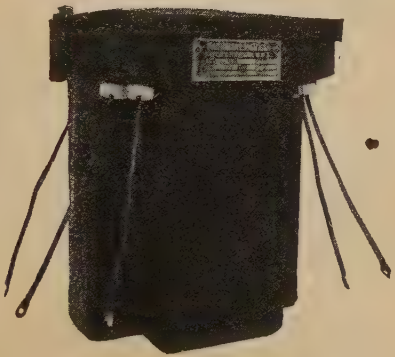
Recording thermometers that will record maximum

KUHLMAN TRANSFORMERS

Station Type



High Voltage
Pole Type



Low Voltage Pole Type

KUHLMAN ELECTRIC CO.

BAY CITY, MICH.

and minimum temperatures for any given period can be purchased for a small sum, and one of these ought to be part of a station equipment; tests on important transformers should be made occasionally and their performance noted.

Losses in a transformer are unavoidable, one cannot be made without some losses, and there is a point in economy of operation beyond which it does not pay to go. Durability should be sought as well as high efficiency. Losses in a well-designed transformer should be kept low enough to never exceed the heat limit above referred to. The temperature of a transformer is the result of the losses; the core or iron loss is constant without regard to the condition of the load on the transformer, but the computed copper losses are present only when the transformer is running at full load, and any increase in load beyond the rated capacity of the transformer will increase these copper losses very materially; however, all transformers should be so designed that a 25 per cent. overload for one or two hours should not increase the losses sufficiently to cause dangerous heat, but beyond 25 per cent. overload under conditions described it is not good practice to go, because of the permanent injury done the transformer, which injury, however, will not be known unless a test is made; it cannot be seen, hence it is very often overlooked.

It is a mistaken economy, however, from every point of view, on the part of the station manager to overload his transformers, except in rare cases, as, for instance, residence lighting on a meter basis. The character of this load is such that the overload is rarely present, and if it should occasionally come on, would remain on only a short time, not long enough for the increased losses to raise the temperature of the transformer beyond the danger point; but where the load is nearly constant for several hours it is very much the safest to have ample transformer capacity. Better invest an extra hundred dollars in additional transformers than to inflict a thousand dollars worth of damages to the ones you already have.

In addition to the injury done with regard to the economy of operation, there is the added danger of injury to the insulation, which is the vital part of a transformer. Should any material defect develop in this, you have what is termed "a burnout," and repairs must be made before further use can be made of the transformer. You have probably bought the trans-

former under a guarantee against this class of trouble, and you will consider this a loss for the manufacturer, but if you will stop to consider a moment, you will find your loss to be about equal to theirs. You lose service revenue, you are called upon to take down the defective transformer and put it up again when rebuilt, and you will probably pay transportation charges at least one way.

Telegraph and Telephone wires should not be placed on the same cross arm with light or power wires. If, however, it is necessary to place telegraph, telephone or other signal circuits on the same poles with lighting and power wires the proper precautions and the latest and most approved methods are treated at considerable length and with many diagrams on page 266 to 301.

EXTRA-HIGH POTENTIAL SYSTEMS
Over 3,500 Volts

Any circuit attached to any machine or combination of machines which develops a difference of potential, between any two wires, of over 3,500 volts, is considered as an extra-high-potential circuit, and as coming under this class, unless an approved transforming device is used, which cuts the difference of potential down to 3,500 volts or less.

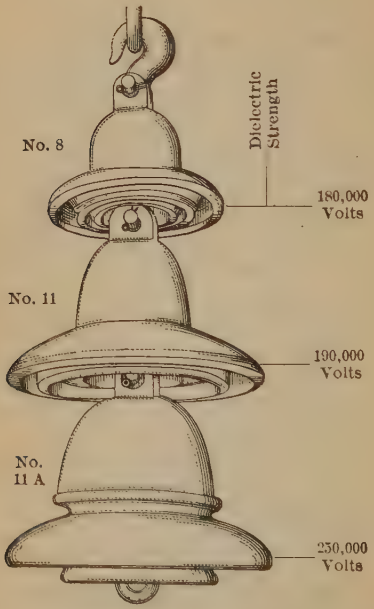
Primary wires carrying over 3,500 volts should never be brought into or over buildings, except power stations and sub-stations.

The secondary wires should be installed under the suggestions given in the section for high-potential system when their immediate primary wires carry a current at a potential of over 3,500 volts, unless the primary wires are installed in accordance with the suggestions given for the construction of constant potential lines of over 5,000 volts, as shown on page 260, or are entirely underground, within city, town and village limits.

Wire for Outside Use has, in most cases, a "weatherproof" (see page 127) insulation, except service wires, which should be "rubber covered" (see page 117). Any insulating covering for wires exposed to the weather on poles is in time rendered useless. The real insulation of the system is dependent upon the porcelain or glass insulators on which the wires are supported.

Constant-Potential Pole Line Circuits of Over 5,000 Volts should be given special care and attention as to their installation and location with respect to adjoining or nearby property or other outside wiring.

Accidental crosses between such lines and low-potential lines may allow the high-voltage current to enter buildings over a large section of adjoining country.



Suspension Insulators for Extra High Voltages.

Insulators for other voltages, see page 250.

Moreover, such high-voltage lines, if carried close to buildings, hamper the work of firemen in case of fire in the building.

It is fully understood that it is impossible to frame rules which will cover all conceivable cases that may arise in construction work of such an extended and varied nature.

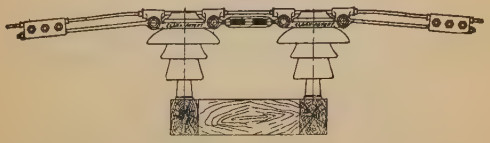
Every reasonable precaution, however, should be taken in arranging routes so as to avoid exposure to contacts with other electric circuits. On existing lines, where there is a liability to contact, the route should be arranged by mutual agreement between the parties interested wherever possible.

Such lines should not approach other pole lines nearer that a distance equal to the height of the taller pole line, and such lines should not be on the same poles with other wires, except that signaling wires used by the company operating the high-pressure system, and which do not enter property other than that owned or occupied by such company, may be carried over the same poles.

When such lines must necessarily be carried near other pole lines, or where they must necessarily be carried on the same poles with other wires, extra precautions to reduce the liability of a breakdown to a minimum should be taken, such as the use of wires of ample mechanical strength, widely spaced cross arms, short spans, double or extra heavy cross arms (see page 248), extra heavy pins, insulators, and poles thoroughly supported. If carried on the same pole with other wires, the high-pressure wires should be carried at least three feet above the other wires.

Where such lines cross other lines, the poles of both lines should be heavy and substantial.

Whenever it is feasible, end insulator guards should be placed on the cross arms of the upper line. If the high-pressure wires cross below the other lines, the wires of the upper line should be dead-ended at each end of the span to double-grooved, or to standard transposition insulators, and the line completed by loops.



Protective Clamping Set for High Tension Crossings.

This set is designed for use at crossings and at such other points as it is essential that the conductor be fastened to the insulator in a most efficient manner. It is approved by the larger Telephone, Railroad and Central Station Companies for use at their crossings.

One of the following forms of construction may be adopted:

The height and length of the cross-over span may be made such that the shortest distance between the lower cross-arms of the upper line and any wire of the lower line will be greater than the length of the cross-over span, so that a wire breaking near one of the upper pins would not be long enough to reach any wire of the lower line. The high-pressure wires should preferably be above the other wires, or

A joint pole may be erected at the crossing point, the high-pressure wires being supported on this pole at least three feet above the other wires. Mechanical guards or supports should then be provided, so that in case of the breaking of any upper wire it will be impossible for it to come into contact with any of the lower wires.

Such liability of contact may be prevented by the use of suspension wires, similar to those employed for suspending aerial telephone cables, which will prevent the high-pressure wires from falling, in case they break. The suspension wire should be supported on high-potential insulators, should have ample mechanical strength, and should be carried over the high-pressure wires for one span on each side of the joint pole; or where suspension wires are not desired guard wires may be carried above and below the lower wires for one span on each side of the joint pole, and so spread that a falling high-pressure wire would be held out of contact with the lower wires (see Clark Method on page 261.

Such guard wires should be supported on high-potential insulators, or should be grounded. When grounded they should be of such size and so connected and earthed that they can surely carry to ground any current which may be delivered by any of the high-pressure wires. Further, the construction should be such that the guard wires will not be destroyed by any arcing at the point of contact likely to occur under the conditions existing.

Whenever neither of the above methods is feasible, a screen of wire should be interposed between the lines at the cross-over. This screen should be supported on high tension insulators or grounded, and should be of such construction and strength as to prevent the upper wires from coming into contact with the lower ones.

If the screen is grounded each wire of the screen must be of such size and so connected and earthed

that it can surely carry to ground any current which may be delivered by any of the high-pressure wires. Further, the construction should be such that the wires of screen will not be destroyed by any arcing at the point of contact likely to occur under the conditions existing.

When it is necessary to carry such high-voltage lines near buildings, they should be at such height and distance from the building as not to interfere with firemen in event of fire; therefore, if within 25 feet of a building, they should be carried at a height not less than that of the front cornice, and the height should be greater than that of the cornice, as the wires come nearer to the building.

It is evident that when the roof of the building continues nearly in line with the walls, as in Mansard roofs, the height and distance of the line should be reckoned from some part of the roof instead of from the cornice.

Poles for Light and Power Wires

It is very essential to a proper installation that the poles receive due consideration, a fact that is too often overlooked.

In selecting the style of pole necessary for a certain class of work the conditions and circumstances should be considered. They may be arranged in three classes, the size of wire they are to carry being one of the important regulating circumstances.

First Class. Alternating-current plants for lighting small towns. Main line of poles should consist of poles of from 30 to 35 feet with 6-inch tops. These are strong enough for all the weight that is placed upon them. No pole less than 30 feet with 6-inch top should be placed on a corner for lamps. The height of trees, of course, will have to be considered in many cases.

Second Class. All poles should have at least 6½-inch tops, and wherever the cross arms are placed on a pole at different angles, the pole should be even thicker at its top.

Third Class. Where heavy wire, such as No. 00, is used for feeder wire, the poles should be at least 7-inch tops. Where mains are run on the same pole line the strain is somewhat lessened.

Cull Poles. The question as to what is a cull pole is something on which many authorities differ. Of course, if specifications call for a certain-sized pole, parties supplying the poles should be compelled to

send the sizes called for. All poles that are smaller at the top than the sizes agreed upon, show signs of dry rot, large knots and bumps, have more than one bend, or have a sweep of over twelve inches, should certainly be classed as cull poles. Specifications for electric light and power work should be, and in many cases are, much more severe than those required by telegraph lines. A cull pole, one of good material, is the best thing for a guy stub, and is frequently used for this purpose. A cedar pole is always preferable to any other, owing to the fact that it is very light in comparison to other timber, and is strong, straight, durable, and very long lived.

Pole Setting. In erecting poles, it seems to be the universal opinion of the best posted construction men that a pole should be set at least five feet in the ground, and six inches additional for every five feet additional length above thirty-five feet, with added depth at corners. Wherever there is much moisture in the ground it is of much value to paint or smear the butt end of the pole with pitch or tar, allowing this to extend about two feet above the level of the ground. This protects the pole from rot at the base. The weakest part of the pole is just where it enters the ground. Never set poles further than 125 feet apart; spacing not over 110 feet is good practice.

Pole Holes should be dug large enough so that the butt of the pole can be dropped straight in without any forcing, and when the pole is in position only one shovel should be used to fill in, the earth being thoroughly tamped down with iron tampers at every step until the hole is completely filled with solidly packed earth. Where the ground is too soft for proper tamping, a grouting composed of one part of Portland cement to two parts of sand mixed with broken stone may be used to make an artificial setting.

Painting. When poles are to be painted, a dark olive green color should be chosen, in order that they may be as inconspicuous as possible. One coat of paint should be applied before pole is set, and one after pole is set. Tops should be pointed and thoroughly painted to shed water.

All poles 45 feet long and over are usually loaded on two cars.

For chestnut poles add 50 per cent. to weights as given in the following table:

CEDAR POLES FOR ELECTRIC LIGHT WORK.

SIZE.	Average weight, pounds each.	No. of Poles to a Car	SIZE.	Average weight, pounds each.	No. of Poles to a Car
25-ft., 5-inch top	200	150	35-ft., 7-inch top	650	90
25 " 5½ " "	225	130	40 " 6 " "	800	80
25 " 6 " "	250	100	40 " 7 " "	900	75
28 " 7 " "	400	80	45 " 6 " "	900	70*
30 " 5 " "	300	110	45 " 7 " "	1000	65*
30 " 6 " "	350	90	50 " 6 " "	1200	55*
30 " 7 " "	420	75	55 " 6 " "	1400	45*
35 " 6 " "	550	100			

*Loaded on two cars.

Cross Arms. The distance from the top of the pole to the cross arm should be equal to the diameter of pole at the top. All cross arms should be well-painted with one coat of paint before placing, and must be of standard size.

Cross arms of four or more pins should be braced, using one or two braces as occasion demands. Cross arms on one pole should face those on the next, thereby making the cross arms on every other pole face in one direction. All wooden pins should have their shanks dipped in paint and should be driven into the cross arm while the paint is wet. The upper part of the pin should also be painted. Put double arms on the pole where feeder wire ends (see page 248).

Guard Irons. Guard irons should be placed at all angles in lines and on break arms (see page 248).

Steps. All junction and lamp poles should be stepped so that the distance between steps on the same side of the pole will not be over 36 inches (see diagrams, pages 280 and 293. Poles carrying transformers should also be stepped.

Guys. All poles at angles in the line should be properly guyed, using No. 4 B. & S. galvanized iron wire,

or two No. 8 wires twisted. . All junction poles should also be guyed (see page 265, and diagram on page 293).

For high tension lines, double or triple petticoat or suspension insulators are recommended (see cuts on pages 250 and 260).

POLE LINE DATA

Gauge No. B. & S.....	4-0	3-0	2-0	1-0	1	2
Diam. Bare wire, in Thousandths	.460	.40964	.3648	.3249	.2893	.2576
Ohms Res. B. wire at 75° per mile	.2622	.33	.4164	.5252	.6642	.8337
Wt. (lbs.) per 1,000 ft. Triple B	775	630	490	400	306	268
Wt. " " Mile " " ..	4092	3326	2587	2112	1616	1415

Poles per Mile	Dist. bet. Poles—Ft.	Approximate Wt. of Weatherproof Wire between Poles					
20	264.00	210.73	171.31	133.24	108.78	83.21	72.87
21	251.40	200.66	163.14	126.87	103.58	77.24	69.39
22	240.10	191.64	155.81	121.17	98.91	75.67	66.27
23	229.56	183.24	148.96	115.85	94.57	72.36	63.36
24	220.00	175.60	142.76	111.03	90.64	69.34	60.72
25	211.20	168.59	137.04	106.58	87.01	66.56	58.29
26	203.07	162.07	131.76	102.48	83.65	64 00	56.05
27	195.55	156.10	126.90	98.69	80.56	61.64	53.97
28	188.55	150.46	122.35	95.16	77.68	59.43	52.05
29	182.09	145.34	118.16	91.89	75.01	57.39	50.26
30	176.00	140.50	114.21	88.83	72.51	55.47	48.58
31	170.80	135.92	110.51	85.95	70.16	53.67	47.00
32	165.00	131.71	107.07	83.28	67.98	52.01	45.55
33	160.00	127.72	103.82	80.75	65.92	50.43	44.16
34	155.29	123.96	100.76	78.37	63.98	48.94	42.86
35	150.85	120.38	97.89	76.14	62.15	47.55	41.64
36	146.66	117.07	95.15	74.02	60.43	46.23	40.48
37	142.70	113.90	92.60	72.02	58.79	44.98	39.39
38	138.96	110.93	90.17	70.13	57.25	43.88	38.36
39	135.38	108.05	87.84	68.33	55.77	42.67	37.37
40	132.00	105.37	85.65	66.62	54.38	41 61	36.43
41	128.78	102.79	83 56	64.99	53.05	40.59	35.54
42	125.71	100.35	81.58	63.44	51.79	39.62	34.70
43	122.79	98.01	79.68	61.97	50.59	38.70	33.89
44	120.00	95.79	77.87	60.56	49.47	37.82	33.12
45	117.33	93.66	76.15	59.21	48.38	36.98	32.38
46	114.78	91.61	74.48	57.93	47.27	36.18	31.68
47	112.34	89.67	72.89	56.70	46 28	35.40	31 01
48	110.00	87.80	71.38	55.52	45.32	34.67	30.36
49	107.75	86.01	69.92	54.38	44.39	33.96	29.74
50	105.60	84.30	68.53	53 29	43.50	33.28	29.15
51	103.52	82.63	67.18	52.24	42.65	32.63	28.57
52	101.53	81.04	65.89	51.24	41.83	32.00	28.02
53	99.64	79.54	64.65	50.29	41.05	31.40	27.50
54	97.77	78.04	63.44	49.34	40.28	30.82	26.98
55	96.00	76.63	65.29	48.45	39.55	30.25	26.50

Gage No. B. & S.	No. 3	No. 4	No. 5	No. 6.	No. 7	No. 8
Diam. Bare Wire, Thousandths	.2294	.2043	.1819	.1620	.1442	.1285
Res. B. Wire, per mile at 75°	1.058	1.333	1.6748	2.114	2.673	3.387
Wt. 1,000 ft. Triple Braid	210	164	145	112		78
Wt. Mile " "	1109	866	766	591		412

Poles Per Mile	Distance Between Poles Feet	Approximate Wt. of Weatherproof Wire between Poles					
20	264.00	57.10	44.59	39.43	30.45	.....	21.21
21	251.40	54.38	42.46	37.54	29.00	.....	20.20
22	240.10	51.93	40.55	35.86	27.70	.....	18.29
23	229.56	49.65	38.77	34.28	26.48	.....	18.44
24	220.00	47.59	37.16	32.86	25.38	.....	17.67
25	211.20	45.68	35.68	31.54	24.36	.....	16.97
26	203.07	43.92	34.30	30.33	23.42	.....	16.32
27	195.55	42.29	33.03	29.21	22.56	.....	15.71
28	188.55	40.78	31.85	28.16	21.75	.....	15.15
29	182.09	39.39	30.76	27.19	21.00	.....	14.63
30	176.00	38.07	29.73	26.29	20.30	.....	14.14
31	170.30	36.83	28.77	25.43	19.64	.....	13.68
32	165.00	35.69	27.87	24.64	19.03	.....	13 26
33	160.00	34.61	27.03	23.90	18.46	.....	12.85
34	155.29	33.59	26.23	23.19	17.91	.....	12.47
35	150.85	32.63	25.48	22.53	17.40	.....	12.12
36	146.66	31.72	24.78	21.90	16.92	.....	11.78
37	142.70	30.87	24.10	21.31	16.46	.....	11.46
38	138.96	30.06	23.47	20.76	16.03	.....	11.16
39	135.38	29.28	22.86	20.22	15.62	.....	10.88
40	132.00	28.55	22.30	19.71	15.23	.....	10.64
41	128.78	27.85	21.75	19.23	14.85	.....	10.31
42	125.71	27.19	21.24	18.78	14.50	.....	10.10
43	122.79	26.56	20.74	18.34	14.17	.....	9.86
44	120.00	25.96	20.27	17.92	13.84	.....	9.64
45	117.33	25.38	19.82	17.52	13.53	.....	9.43
46	114.78	24.83	19.39	17.14	13.24	.....	9.22
47	112.34	24.30	18.98	16.78	12.96	.....	9.02
48	110.00	23.79	18.58	16.43	12.69	.....	8.84
49	107.75	23.31	18.20	16.09	12.43	.....	8.66
50	105.60	22.84	17.84	15.77	12.18	.....	8.48
51	103.52	22.39	17.49	15.46	11.95	.....	8.32
52	101.53	21.96	17.15	15.16	11.71	.....	8.16
53	99.64	21.55	16.83	14.88	11.49	.....	8.00
54	97.77	21.15	16.51	14.60	11.28	.....	7.85
55	96.00	20.76	16.21	14 34	11.07	.....	7.71

The strength of soft copper wire varies from 32,000 to 36,000 pounds per square inch, and of hard copper wire from 45,000 to 68,000 pounds per square inch, according to the degree of hardness.

General Specifications for the Construction of Jointly Used Wood Pole Lines Carrying Supply Circuits (Light and Power) and Signal Circuits (Telephone and Telegraph).

1. **Definitions—Supply Circuit.** Any circuit used for the supply of electrical energy for lighting, power or railway purposes and all circuits not classed as signal circuits.

Signal Circuit. Any circuit used for public or private communication or signaling purposes, and devoted exclusively to the transmission of signals or intelligence, which operates at not exceeding 400 volts to ground, or 750 volts between any two points of the circuit, and the transmitted power of which does not exceed 150 watts. Below 150 volts no limit is placed on the power capacity of the system.

Attachments. Cross arms, line wires, guy wires cables, apparatus, fixtures, or any other appurtenances carried on any pole covered by these specifications.

Line Wire. Any wire (solid or stranded) extending from one pole to another except:

(a) Guy wire.

(b) Suspension wire, including cable and wires supported by such suspension wire.

(c) Trolley contact wire.

(d) Trolley span wire.

(e) Lamp suspension wire.

Lightning Protection Wire. A line wire consisting of a grounded conductor carried along a pole line at or above the tops of the poles for the purpose of protecting against lightning.

Suspension Wire. A wire used for supporting wires or cable in rings or hangers.

Cable. A combination of conductors insulated from one another and having a common covering or sheath.

Ground Wire. A conductor run vertically on a pole with one end connected to a transformer secondary, a lightning protection wire, or other object to be grounded and its other end connected to a water pipe system, driven ground rod, buried metal plate, or other object affording a conducting path into the earth.

Reverse Work. Construction on corner or junction poles where additional cross arms out of parallel with the normal cross arms are used for changing the direction of the line or for branch lines.

Street Side of Pole.—The side of a pole toward the street, highway or alley. At street intersections, the street side shall be designated by agreement.

Field Side of Pole.—The side of a pole opposite the street side.

2. **Classes of Circuits.** For convenience the different kinds of circuits covered by these specifications are classified as follows:

SUPPLY CIRCUITS

Class	Character and Operating Voltage or Current
B	Constant potential, alternating current, not exceeding 5,000 volts between wires (or 2,900 volts normally to ground); constant potential direct current, not exceeding 750 volts (for exception, see D); constant current, series metallic, line current not exceeding 7.5 amperes.*
D	Constant potential, direct current, trolley contact wires and feeders, not exceeding 750 volts to ground.

*Systems using lamps operating at currents in excess of 7.5 amperes but equipped with compensators or transformers so that the line current does not exceed 7.5 amperes are included in Class B.

SIGNAL CIRCUITS

C	Commercial telephone, telegraph, call box or other signal circuits for public use.
P	Private telephone or other signal circuits used by the owners or operators of Class B or Class D circuits and to which the public does not have access.

3. **Scope and Limitation.** These specifications shall apply to all construction on wood poles used jointly for Class C circuits and Class B and Class D circuits as defined and limited in Sections 1 and 2 hereof.

Joint use of poles by Class C circuits and supply circuits carrying voltage or current in excess of the limits in Section 2 hereof is not covered by these specifiations.

The methods of construction specified herein are in conformity with the provision of the National Electrical Safety Code. These methods have been found by experience to make possible the joint use of poles

under the conditions covered by these specifications in a safe and satisfactory manner. It is recognized that in the development of the art other safe and satisfactory methods of construction may be devised. The fact that particular methods of construction are required herein does not preclude consideration at any time by the parties hereto of other methods of construction and the incorporation in the specifications of any such other methods which the parties hereto may mutually agree upon as being safe and satisfactory.

4. **Relative Positions of Attachments.** The relative positions on a pole of the spaces to be occupied by attachments of the different classes, except as otherwise permitted in Sections 10, 12 and 13, shall be from the top of the pole downward:

Class B
Class C
Class D

Class P attachments shall be within the space occupied by the class in connection with which they are used. Where both Class B and Class D attachments are present on a pole, Class P attachments may occupy either the Class B or Class D position.

Class D trolley feeders, in sections where they are not tapped to trolley contact wires, may, if desired, be placed in the Class B position.

3. **Vertical Clearance.** Except as provided in Sections 10, 12 and 13, the vertical separation at the pole, between Class B and Class C attachments and between Class C and Class D attachments shall be not less than the values shown below:

Between Class B and C

Crossarms (center to center).....	48 inches
Other attachments (crossarm braces* and guys excepted).....	40 inches

*Where crossarm braces are attached to metal crossarms, or are in contact with transformer cases or hangers, they are subject to the same clearance requirements as the other attachments.

Between Class C and Class D

Crossarms (center to center).....	48 inches
Other attachments (crossarm braces* and guys excepted).....	40 inches

Line wires or suspension wires of different classes where strung at different sags shall have vertical spacings at the supporting structures so adjusted that the minimum spacing at any point in the span at 60 degrees F. with no wind, shall not be reduced more than 25 per cent. from the above values.

6. **Climbing Space.** A clear climbing space of at least thirty inches between attachments shall be maintained up the pole but need only be on one side or corner of the pole.

Where reverse work is employed the attachments shall be so located and maintained as to provide and keep open on one side of the pole and next to the pole, as a vertical climbing space, a square of not less than thirty inches on a side. The pole itself and crossarm back braces may be included within the climbing space so measured.

TENSILE STRENGTH OF COPPER WIRE.

Numbers, B. & S. G.	Breaking weight, Pounds.		Numbers, B. & S. G.	Breaking weight. Pounds.	
	Hard-drawn.	Annealed.		Hard-drawn.	Annealed
0 000	8 310	5 650	9	616	349
000	6 580	4 480	10	489	277
00	5 226	3 553	11	388	219
0	4 558	2 818	12	307	174
1	3 746	2 234	13	244	138
2	3 127	1 772	14	193	109
3	2 480	1 405	15	153	87
4	1 967	1 114	16	133	69
5	1 559	883	17	97	55
6	1 237	700	18	77	43
7	980	555	19	61	34
8	778	440	20	48	27

7. **Line Wires on Crossarms.** All single line crossarms on any pole shall be upon the same side of such pole. Line wires other than lightning protection wires shall be attached to insulators supported on crossarms except as otherwise provided in this section and in Section 8. One line wire may be carried on a ridge pin above the top of the pole. All line wires carried on crossarms shall clear the surface of the pole by not less than five inches.

Class B secondary wires not exceeding 250 volts to ground may be carried on suitable insulators on metal brackets or racks attached directly to the pole.

Class C wires for local distribution may be attached directly to the pole, provided that such wires are insulated with a standard rubber compound or its equivalent in insulation, and covered with at least one thickness of braided or woven covering. When such wires are carried along the line and attached directly to the poles they shall conform to the same requirements respecting climbing space as are set forth in Section 8 for wires or cables supported by suspension wires along the line.

EQUIVALENT CROSS SECTIONS OF WIRES.

BROWN & SHARP GAGE

6000	2— 0	4— 3	8— 6	16— 9	32—12	64—15	128—18
000	2— 1	4— 4	8— 7	16—10	32—13	64—16	.....
00	2— 2	4— 5	8— 8	16—11	32—14	64—17	1 and 3
0	2— 3	4— 6	8— 9	16—12	32—15	64—18	2 " 4
1	2— 4	4— 7	8—10	16—13	32—16	.....	3 " 5
2	2— 5	4— 8	8—11	16—14	32—17	.....	4 " 6
3	2— 6	4— 9	8—12	16—15	32—18	.....	5 " 7
4	2— 7	4—10	8—13	16—16	.....	.....	6 " 8
5	2— 8	4—11	8—14	16—17	.....	.....	7 " 9
6	2— 9	4—12	8—15	16—18	.....	.....	8 " 10
7	2—10	4—13	8—16	.....	.....	.....	9 " 11
8	2—11	4—14	8—17	....	.....	.....	10 " 12
9	2—12	4—15	8—18	.....	.....	.....	11 " 13
10	2—13	4—16	.....	.....	.....	.....	12 " 14
11	2—14	4—17	.....	.....	.....	.....	13 " 15
12	2—15	4—18	.....	.....	.....	.....	14 " 16
13	2—16	.....	.....	.....	.....	.....	15 " 17
14	2—17	.....	.....	.....	.....	.....	16 " 18
15	2—18	.....	.....	.....	.....	.....	.....

8. Cables or Wires on Suspension Wires or Racks. Suspension wires carrying cables or Class C wires may be attached directly to the pole. Where more than one such suspension wire is attached directly to the pole below attachments of another class, all shall be on the same side of the pole. Where suspension wires, carrying Class C wires or cables, are attached directly to the pole, they shall be placed on the field side of the pole, except that in alleys where poles are located close to buildings the cable may be carried on the alley side. Where any suspension wire is attached directly to the pole below attachments of another class, the full climbing space of thirty inches horizontally from the suspension wire shall be maintained for a distance

of 48 inches vertically above and below the suspension wire. This climbing space may be either on the field side or street side of the pole.

Where a suspension wire, carrying Class C cable or wires, is attached directly to the pole and the suspension wire is less than 72 inches below the lowest Class B attachment in the Class B space, a wooden guard arm shall be attached to the pole immediately above and substantially parallel to such suspension wire. The guard arm shall be at least 48 inches in length and shall be securely fastened to the pole. On corner poles, where the cable turns, the guard arm shall be placed along the climbing side of the pole.

9. **Lateral Wires.** Connections to wires or apparatus upon a pole may be run laterally across the pole, provided that, where such connections are below wires of another class, the wires crossing the pole shall

(a) Have standard rubber insulation of a thickness specified in Section 10 (or its equivalent in insulation) and a braided or woven covering.

(b) Except in the case of Class C and Class P wires, be carried on insulators on pins or brackets on the face of the crossarm. Class C or Class P wires may be attached either to the sides or bottom of the crossarm.

10. **Vertical Wires.** Wires or cables run vertically upon a pole, except above a point not less than forty inches vertically above the highest Class C attachment, shall comply with the following requirements:

(a) Class B and Class D vertical wires and cables shall as far as practicable be placed on the street side of the pole. Class C vertical wires and cables shall, as far as practicable, be placed on the field side of the pole.

(b) All vertical wires and cables shall be so arranged as not to interfere with the use of the pole steps.

(c) Twisted pair wires from a Class C terminal box to a Class C arm or bracket may be attached directly to the pole, but wholly within the Class C position.

(d) Vertical conductors except ground wires shall have an insulation consisting of a standard rubber compound of the thickness specified below (or its equivalent in insulation) covered by at least one thickness of weatherproof braided or woven covering.

Size of Conductor.	Minimum thickness in sixty-fourths of an inch of rubber insulation for maximum operating voltage				
	600	1500	2500	3500	5000
No. 18 to No. 15 A. W. G.....	2				
No. 14 to No. 8 A. W. G.....	3	4	6	8	12
No. 7 to No. 2 A. W. G.....	4	5	6	8	12
No. 1 to No. 0000.....	5	6	7	8	12
225,000 to 500,000 c.m.....	6	7	8	9	12
525,000 to 1,000,000 c.m.....	7	8	9	10	12
Over 1,000,000 c.m.....	8	9	10	11	14

(e) Vertical runs of Class B conductors shall be made on insulators or shall be enclosed in conduit as specified for metal sheathed cables in "h" below. Where not carried in conduit, the wire shall be carried down the pole taut and fastened upon standard insulators which shall be supported upon pins or brackets so located and maintained that the conductors will be firmly held at a distance of approximately five inches from the surface of the pole.

(f) For vertical runs of two or three Class B wires of the same circuit on insulators, as provided in "e" above, multiple conductor wire or cable shall be employed. Each conductor shall be insulated in accordance with the above table and each group of insulated wires shall be covered by at least one thickness of weather-proof braided or woven covering.

(g) Vertical runs of Class D conductors shall be insulated and run as specified in "e" above.

(h) Vertical runs of Class B or Class D metal sheathed cable shall be enclosed within a conduit of suitable insulating material, for their entire length except that, where more than six feet below the lowest Class C attachment, (or Class D attachment, if there are Class D attachments on the pole), iron pipe may be used. Such conduit and pipe shall be securely fastened to the pole.

(i) All vertical runs of Class C metal sheath cable which run through wires of another class shall be enclosed within a conduit of suitable insulating material between points not less than six feet below and forty inches above such wires. Such conduit shall be securely fastened to the pole.

(j) Ground wires to Class D attachments and any

ground wires which pass through attachments of another class shall be enclosed within a conduit of suitable insulating material between points not less than six feet below and forty inches above such attachments. Ground wires shall be protected from mechanical injury for at least eight feet above the ground by a suitable protective covering. Such conduit and covering shall be securely fastened to the pole.

(k) The same ground wire shall not be used for Class C attachments and attachments of any other class, and where practicable ground wires or connections to underground wires of more than one class shall not be attached to the same pole.

11. **Apparatus.** Cable boxes, switches, cutouts and similar apparatus may be installed on the pole at a height convenient for operation, provided:

(a) They do not interfere with climbing the pole.
(b) The requirements as to vertical spacing are observed, as provided in Section 5.
(c) They do not prevent the installation of vertical runs, as provided in Section 10.

Such apparatus when located below Class C attachments shall be of a type in which all live parts are covered and protected from accidental contact.

Transformers shall not be located below Class C attachments, except in special cases when transformers have to be placed on a joint pole which are too heavy to be carried in the Class B position (in general, transformers of over a total capacity of 50 K.W.).

12. **Fixtures for Electric Lamps.** Span wires or brackets for street lamps may be attached to poles jointly used, and street lamps operated upon either the arc or incandescent system may be maintained upon the same, provided the fixtures and lamps shall conform to the following requirements of this section.

No fixture or any of its metal parts shall completely encircle the pole, but shall be restricted to the half of the pole toward the lamp, except that span wires or brackets may be attached by bolts passing through the pole.

No street lamp, or fixture, or any brace or guy therefrom, shall come within 24 inches of any railway span wire or bracket, or any crossarm or line wire other than Class B.

All exposed metal parts of lamps and of lamp sup-

ports, unless effectively insulated from the parts carrying currents, shall be maintained not less than 20 inches from the surface of the pole and not less than 48 inches, measured horizontally, from a trolley contact wire.

The vertical clearance between lamp fixtures and suspension wires carrying Class C wires or cables shall be not less than 12 inches. Where practicable, Class C cable terminals shall be not less than 12 inches vertically from the fixture, but where this clearance cannot be obtained, all metal parts of terminals shall have the greatest practical separation from lamp fixtures, including all supporting screws and bolts of both classes of attachments.

The lamp and its electrical connections shall be effectually insulated from its supporting fixture by insulation of adequate mechanical strength and capable of withstanding, when wet, a breakdown test of at least twice the maximum voltage of the circuit to which the lamp is connected. A strain insulator shall be inserted in every lamp span wire six to eight feet from the pole.

13. **Railway Span Wires and Brackets.** Span wires or brackets for supporting or holding trolley contact wires and guard wires may be attached to poles jointly used at a height convenient for their operation, and not necessarily below the Class C attachments, provided they conform to the following requirements of this section.

The span wires or brackets shall not completely encircle the pole, but shall be restricted to the side of the pole toward the trolley contact wire, except that through bolts may be used in fastening them to the pole.

All such span wires and brackets shall be effectually insulated from the railway voltage. A strain insulator shall be inserted in every span wire six to eight feet from the pole or in the case of a trolley bracket, a strain insulator shall be placed on each side of the trolley contact wire support. The insulation between the trolley contact wire or feeder tap and the pole shall be capable of withstanding, when wet, a voltage equal to at least twice the voltage of the trolley circuit.

The vertical clearance between span wires or brackets, supporting trolley wires, and the nearest Class C crossarm shall be not less than 24 inches. On short railway poles Class C twisted pair wires may be car-

ried at the top of the pole with a clearance of not less than 12 inches. The vertical clearance between railway span wires or brackets and suspension wires carrying Class C cables or wires shall be not less than 12 inches. Where practicable, Class C cable terminals shall be not less than 12 inches vertically from the fixture, but where this clearance cannot be obtained, all metal parts of terminals shall have the greatest practicable separation from trolley fixtures, including all supporting screws and bolts of both classes of attachments.

14. **Line Wires.** Line wires of supply circuits shall be of a size not less than:

Hard or medium-drawn copper, No. 8 A. W. G.

Soft-drawn copper, No. 6 A. W. G.

Line wires of signal circuits, which occupy a position above line wires or cables of another class, shall be of a size not less than:

Single wire, hard-drawn copper, No. 10 A. W. G. (No. 12 N. B. S. G.).

Twisted pair, hard-drawn copper, each wire, No. 14 A. W. G.

Twisted pair, copper-covered steel, each wire, No. 17 A. W. G.

Material other than copper may be used for line wires provided the wires of such other material have a strength not less than that of the wires specified above; but no iron or steel line wires (except lightning protection wires as provided below, shall be used above line wires or cables of another class except in regions where experience has shown that iron or steel is not subject to serious corrosion and where so used shall be galvanized.

Lightning protection wires of iron or steel, of a size not less than No. 4 Stl. W. G., may be used except in locations where corrosion of iron or steel is unusually severe.

15. **Pole Steps.** All jointly used poles which carry vertical wires or cable shall be equipped with pole steps. The lowest step shall be not less than 6.5 feet from the ground, except that a wood block may be placed on one side only of the pole not less than 3.5 feet from the ground.

16. **Guys.** All guys, except anchor guys, shall preferably be attached to non-conducting supports and so placed and maintained that no part of any guy shall come within eight feet of the ground.

All guys shall be so placed as to maintain a clearance

of at least six inches from the nearest line wire on the guyed pole.

Every guy which passes over or under any electric wires other than those carried upon the guyed pole, shall be so placed and maintained as to provide at all times a clearance of not less than two feet between the guy and such electric wires.

No guy shall be placed or maintained in contact with any other guy, except where attached to the pole, stub or anchor, nor in any case, in contact with a lead-covered cable, suspension wire or ground wire.

Every guy wire attached to a pole jointly used shall be insulated by the insertion of one or more strain insulators, according to its length and condition, as follows:

(a) One strain insulator shall be placed in every guy at a point between six and eight feet in horizontal distance from the pole, except that, in short guys, where a point six feet from the pole would be less than eight feet above the ground, the strain insulator shall be placed eight feet in vertical distance from the ground.

(b) A second strain insulator shall be placed in every guy, except those attached to a wood guy stub at a point more than eight feet above the ground. The second strain insulator shall be placed at a point between six and eight feet from the object to which the farther end of the guy is attached, except that where this point is less than eight feet above the ground, the second strain insulator shall be placed eight feet in vertical distance from the ground. In anchor guys the strain insulator shall be placed between eight and ten feet vertically from the ground.

(c) In short guys in which the two strain insulators here required would be located within five feet of each other, only one strain insulator need be used.

Strain insulators used in guys shall be at least equal in mechanical strength to the tensile strength of the guys in which they are used. They shall be preferably of the interlocking type.

Strain insulators used in guys shall not flash over at twice the maximum line voltage under a uniform precipitation equivalent to one-fifth inch of rain per minute at an angle of 45° to the axis of the insulator.

17. Induction and Leakage. All supply and signal circuits and their connected apparatus shall be constructed, operated and maintained with due regard to avoiding or minimizing interference, by induction or by leakage, to the service given over the signal circuits. Where such interference is experienced, those measures shall be applied which will most conveniently and economically avoid or minimize the interference.

18. Plates. Plates 1 to 13, inclusive, shown on pages 380 to 393, supplement and form a part of these specifications. These plates merely show arrangement of attachments, clearances, etc., and are not intended to illustrate specific types of construction which are required.

Appendix "A"

SAGS AT 60° F. FOR MEDIUM AND HARD DRAWN COVERED COPPER WIRES—SPAN LENGTHS.

No.	100	125	150	175	200	250	300	400	500
6	18	27	40	—	—	—	—		
4	12	18	27	36	48	—	—		
2	12	18	27	30	36	60	96		
1	12	18	26	29	33	52	80		
00	12	18	25	28	31	46	66		
0000	12	18	24	27	30	38	50		

SAGS AT 60° F. FOR SOFT DRAWN COVERED COPPER WIRES—SPAN LENGTHS.

	100	125	150	175	200	250	300	400	500
4	21	32	48	—	—				
2	18	27	40	54	—				
1	15	22	33	45	60				
00	12	18	25	33	42				
0000	12	18	24	30	36				

SAGS AT 60° F. FOR MEDIUM AND HARD DRAWN BARE WIRES—SPAN LENGTHS.

	100	125	150	175	200	250	300	400	500
6	12	18	27	—	—	—	—	—	—
4	10	15	21	28	38	71	115	—	—
2	10	15	18	21	24	44	68	138	228
1	10	15	18	21	24	40	59	120	204
00	10	15	18	21	24	36	50	102	168
0000	10	15	18	21	24	32	42	84	132

Specifications for the Construction of Jointly Used Wood Pole Lines Carrying Class A Supply Circuits and Class C Signal Circuits

1. Definition of Class A Supply Circuits. For the purpose of these specifications Class A supply circuits are defined as constant potential, alternating current

circuits exceeding 5,000 volts between conductors (or 2,900 volts normally to ground) and constant current series metallic circuits with line current exceeding 7.5 amperes.

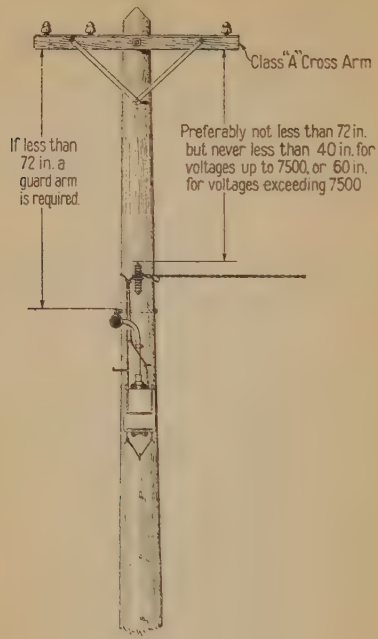

Class "A" Cross Arm
If less than 72 in. a guard arm is required.
Preferably not less than 72 in. but never less than 40 in. for voltages up to 7500, or 60 in. for voltages exceeding 7500

PLATE A
SHOWING CLASS "A" CROSS-ARM AND CLASS "C" CABLE

2. **Application.** These specifications shall apply to all wood pole lines used jointly for Class A supply circuits and Class C signal circuits.

3. **Inclusion of Requirements of "Exhibit 1."** These specifications are to be considered and used in connection with the specifications marked "Exhibit 1," entitled,

"General Specifications for the Construction of Jointly Used Wood Pole Lines Carrying Supply Circuits and Signal Circuits," all the requirements of which, except as modified herein, are hereby included and made part of these specifications.

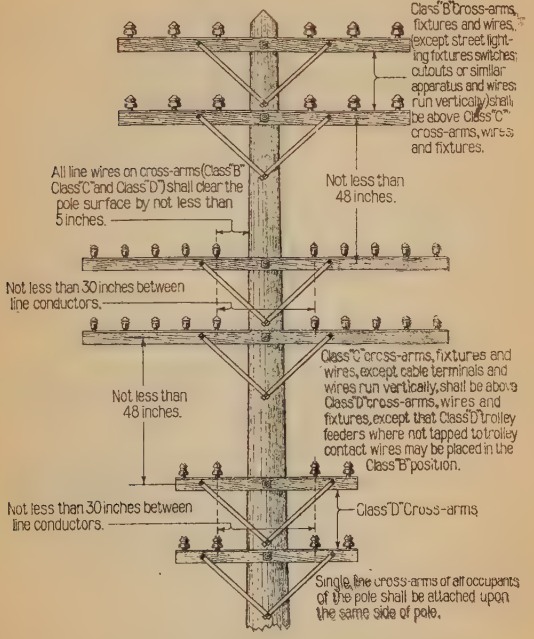

Class "B" cross-arms, fixtures and wires, except street lighting fixtures switches, cutouts or similar apparatus and wires run vertically shall be above Class "C" cross-arms, wires and fixtures.
All line wires on cross-arms (Class "B" Class "C" and Class "D") shall clear the pole surface by not less than 5 inches.
Not less than 48 inches.
Not less than 30 inches between line conductors.
Class "C" cross-arms, fixtures and wires, except cable terminals and wires run vertically, shall be above Class "D" cross-arms, wires and fixtures, except that Class "D" trolley feeders where not tapped to trolley contact wires may be placed in the Class "B" position.
Not less than 48 inches.
Not less than 30 inches between line conductors.
Class "D" Cross-arms
Single line cross-arms of all occupants of the pole shall be attached upon the same side of pole.

PLATE 1
RELATIVE POSITION OF ATTACHMENTS OF THE DIFFERENT CLASSES, SHOWING VERTICAL CLEARANCES AND CLIMBING SPACE.

4. Grades of Construction. Depending on the voltage or current of the Class A circuits one of the following two grades of construction shall be employed, the requirements for which are set forth on next page.

Class A Circuits	Grade of Construction
Constant potential, alternating current circuits exceeding 7500 volts between conductors (or 4400 volts normally to ground).	Grade A
Constant current, series metallic circuits line current exceeding 10 amperes.	
Constant potential, alternating current circuits, 5000 to 7500 volts between conductors (or 2900 to 4400 volts normally to ground). Constant current series metallic circuits, line current 7.5 to 10 amperes.	Grade B

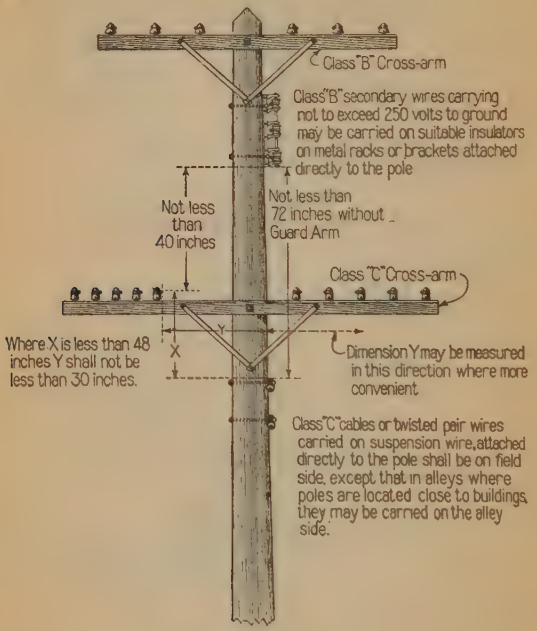

Class "B" Cross-arm
Class "B" secondary wires carrying not to exceed 250 volts to ground may be carried on suitable insulators on metal racks or brackets attached directly to the pole
Not less than 40 inches
Not less than 72 inches without Guard Arm
Class "C" Cross-arm
Where X is less than 48 inches Y shall not be less than 30 inches.
X
Y
Dimension Y may be measured in this direction where more convenient
Class "C" cables or twisted pair wires carried on suspension wire, attached directly to the pole shall be on field side, except that in alleys where poles are located close to buildings, they may be carried on the alley side.

PLATE 2
CLASS "B" SECONDARY WIRES AND CLASS "C" SUSPENSION WIRES ATTACHED DIRECTLY TO THE POLE, SHOWING ARRANGEMENT OF ATTACHMENTS AND CLEARANCES

Where the Class A circuits are all in cable as provided in Section 11 of these specifications the poles are not required to comply with the strength requirements of Grades A or B construction.

5. **Application of Grades A and B Construction.** The requirements for Grades A or B construction shall apply to all Class A attachments and their supporting structures, but do not apply to attachments of Classes

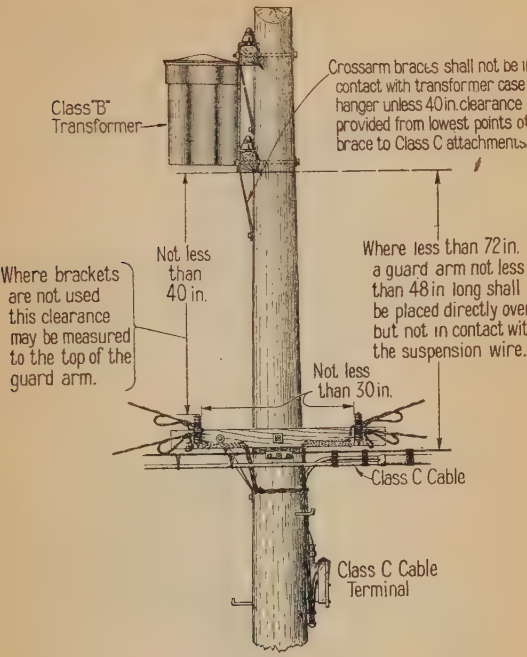

Class "B" Transformer
Crossarm braces shall not be in contact with transformer case or hanger unless 40 in. clearance is provided from lowest points of brace to Class C attachments.
Where brackets are not used this clearance may be measured to the top of the guard arm.
Not less than 40 in.
Where less than 72 in. a guard arm not less than 48 in long shall be placed directly over but not in contact with the suspension wire.
Not less than 30 in.
Class C Cable
Class C Cable Terminal

PLATE 3

LOCATION OF CLASS "B" TRANSFORMER, SHOWING VERTICAL CLEARANCE. USE OF GUARD-ARM ABOVE CLASS "C" CABLES.

B, C or D, which are located below the Class A space. Where Class B, Class C or Class D circuits are located above Class A aerial cable, they are not thereby required to comply with Grades A or B construction.

6. **Position of Class A Circuits.** The Class A circuits shall occupy a position above all other classes of attachments on the pole, except that Class A aerial cables may be below Class B circuits.

7. **Vertical Clearance.** The vertical separation at the pole except for vertical runs, between Class A attachments and Class C attachments shall be prefer-

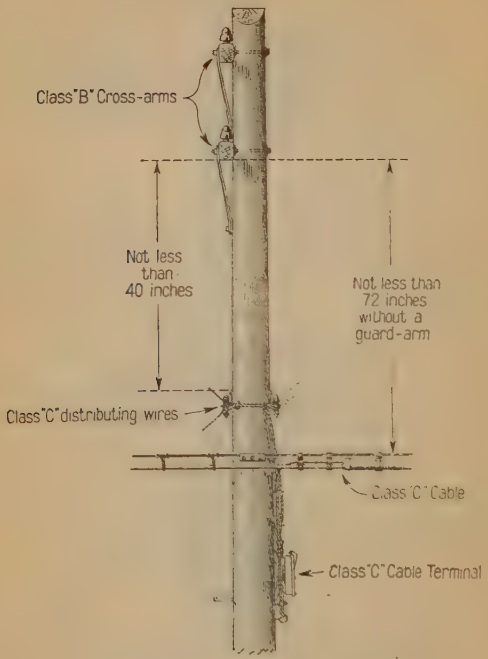

Class "B" Cross-arms
Not less than 40 inches
Not less than 72 inches without a guard-arm
Class "C" distributing wires
Class "C" Cable
Class "C" Cable Terminal

PLATE 4
CLASS "C" CABLE AND DISTRIBUTING WIRES WHERE GUARD-ARM IS NOT NECESSARY

ably not less than six feet, and in no case shall the separation between Class A and Class C attachments be less than the following:

	Not Exceeding 7500 volts	Exceeding 7500 volts
Crossarms (center to center)	48 inches	72 inches
Other attachments (crossarm braces* and vertical runs excepted)	40 inches	60 inches

*Where the crossarm braces are attached to metal crossarms they are subject to the same clearance requirements as the other attachments.

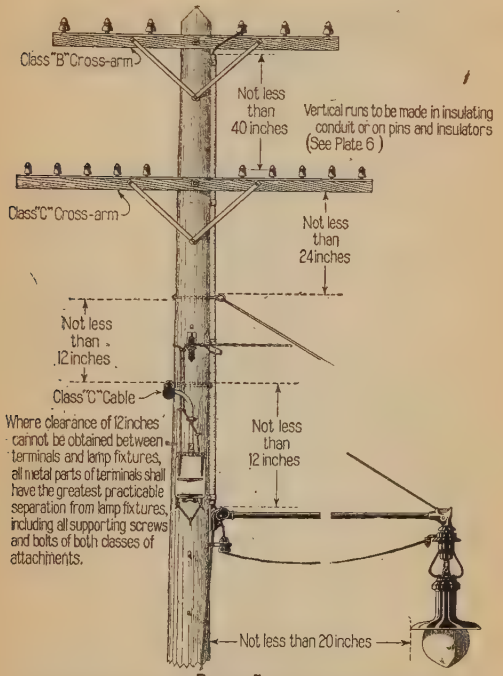

Class "B" Cross-arm
Not less than 40 inches
Vertical runs to be made in insulating conduit or on pins and insulators (See Plate 6)
Class "C" Cross-arm
Not less than 24 inches
Not less than 12 inches
Class "C" Cable
Where clearance of 12 inches cannot be obtained between terminals and lamp fixtures, all metal parts of terminals shall have the greatest practicable separation from lamp fixtures, including all supporting screws and bolts of both classes of attachments.
Not less than 12 inches
Not less than 20 inches

PLATE 5

ARC LAMP BELOW CLASS C ATTACHMENTS ON JOINTLY USED POLE SHOWING USE OF INSULATING CONDUIT FOR VERTICAL RUN

8. Conductor Separation. The minimum normal separation of Class A line wires shall be not less than twelve inches for voltages not exceeding 7,500. For higher voltages this separation shall be increased by four-tenths inch per kilovolt excess above 7,500 volts.

When conductors of circuits of different voltages are concerned, the voltage to be taken in applying this rule shall be that of the higher voltage circuit.

9. **Class A Branch Connections.** Branch connections on pin insulators from Class A wires shall be

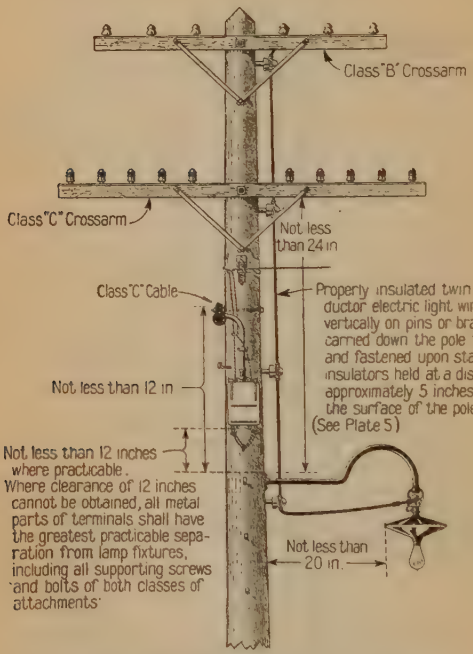

Class "B" Crossarm
Class "C" Crossarm
Not less than 24 in
Class "C" Cable
Properly insulated twin conductor electric light wire run vertically on pins or brackets carried down the pole taut and fastened upon standard insulators held at a distance approximately 5 inches from the surface of the pole (See Plate 5)
Not less than 12 in
Not less than 12 inches where practicable. Where clearance of 12 inches cannot be obtained, all metal parts of terminals shall have the greatest practicable separation from lamp fixtures, including all supporting screws and bolts of both classes of attachments
Not less than 20 in.

PLATE 6.
INCANDESCENT LAMP ON JOINTLY USED POLE SHOWING USE OF TWIN CONDUCTOR ON PINS AND INSULATORS FOR VERTICAL RUN

made from double crossarms placed at right angles to and over or under the crossarm carrying the supply wires to which connection is made. In making branch connections care shall be taken not to weaken the supply wires

10. **Vertical Class A Connections.** Class A circuits may be run vertically upon a pole provided that where below a point not less than forty inches above the highest Class C attachment for voltages up to 7,500 or not less than sixty inches for voltages above 7,500, they shall comply with the following requirements:

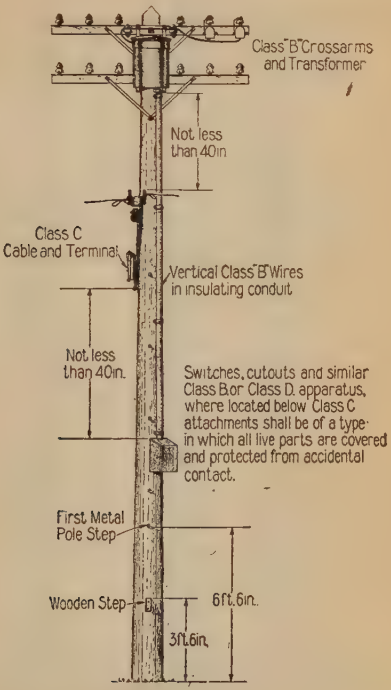
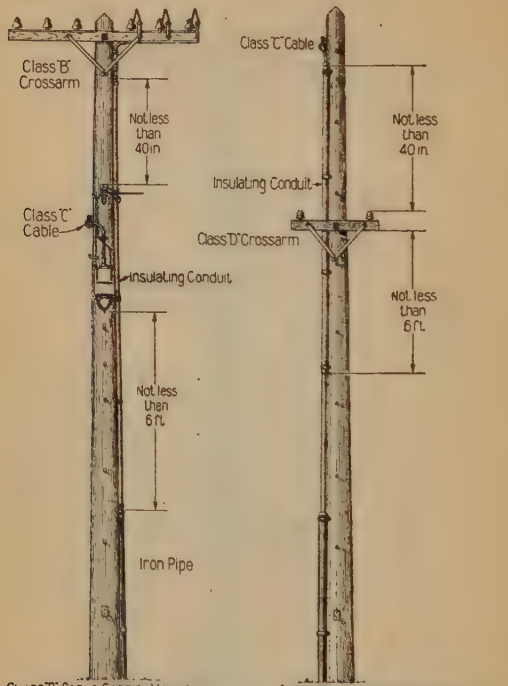

Class "B" Crossarms and Transformer
Not less than 40in
Class C Cable and Terminal
Vertical Class "B" Wires in insulating conduit
Not less than 40in.
Switches, cutouts and similar Class B or Class D. apparatus, where located below Class C attachments shall be of a type in which all live parts are covered and protected from accidental contact.
First Metal Pole Step
Wooden Step
6ft. 6in.
3ft. 6in.

PLATE 7
LOCATION OF SWITCHES, CUTOUTS OR SIMILAR APPARATUS BELOW CLASS C ATTACHMENTS

The vertical Class A circuits shall be in multiple conductor cable so insulated as to be capable of withstanding at least twice the normal line voltage between any two conductors. Except in the case of constant current circuits carried on pins and insulators approximately five inches from the surface of the pole, the

vertical cable shall be enclosed within a conduit of suitable insulating material except that, where more than six feet below the lowest attachment of any other class, iron pipe may be used. If the vertical cable is an extension of an aerial or underground cable it shall



CLASS 'B' CABLE CARRIED VERTICALLY IN CONDUIT THROUGH CLASS 'C' ATTACHMENTS

CLASS 'C' CABLE CARRIED VERTICALLY IN CONDUIT THROUGH CLASS 'D' ATTACHMENTS

PLATE 8

be covered with a metal sheath or armor which is effectively grounded and the insulation shall be capable of withstanding at least twice the normal line voltage between any two conductors and between any conductor and the metal sheath or armor.

Ground wires to Class A attachments shall be en-

closed within a conduit of suitable insulating material throughout their entire length, except that where more than six feet below the lowest attachment of any other class, iron pipe or other suitable mechanical protective covering may be used.

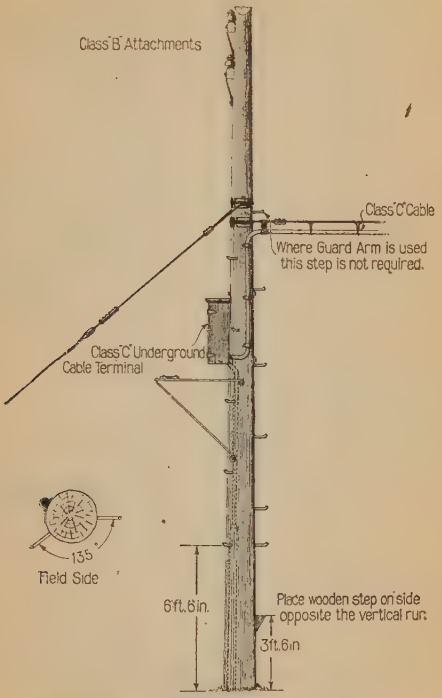

Class 'B' Attachments
Class 'C' Cable
Where Guard Arm is used this step is not required.
Class 'C' Underground Cable Terminal
135
Field Side
6ft. 6in.
Place wooden step on side opposite the vertical run
3ft. 6in

PLATE 9
POLE CARRYING UNDERGROUND CLASS C CABLE TERMINAL SHOWING METHOD OF STEPPING

11. **Class A Aerial Cable.** Class A circuits may be carried in aerial cables attached directly to the poles provided that the following requirements are complied with:

(a) The cable shall be supported in rings or hangers

carried by a suspension wire attached to the pole by means of a three-bolt clamp and a through bolt placed not less than ten inches below the top of the pole (see Sections 21 to 24, inclusive).

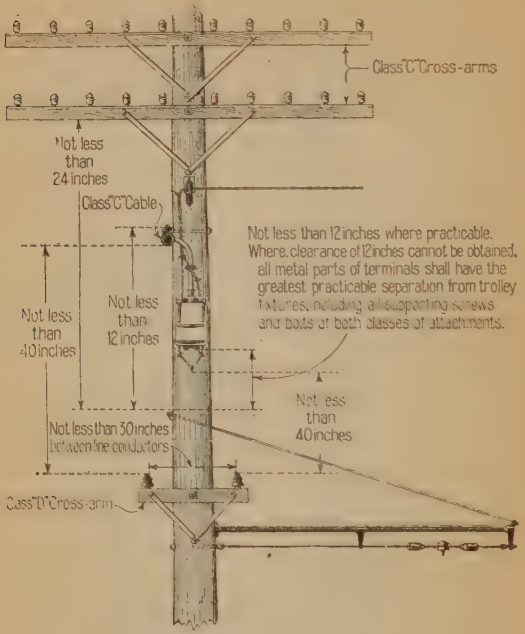

Class 'C' Cross-arms
Not less than 24 inches
Class 'C' Cable
Not less than 12 inches where practicable. Where clearance of 12 inches cannot be obtained, all metal parts of terminals shall have the greatest practicable separation from trolley fixtures, including all supporting screws and bolts of both classes of attachments.
Not less than 40 inches
Not less than 12 inches
Not less than 40 inches
Not less than 30 inches between line conductors
Class 'D' Cross-arm

PLATE 10
SHOWING TROLLEY BRACKET CONSTRUCTION

(b) The cable shall be covered with a metal sheath or armor.

(c) The conductors of the cable shall be so insulated as to be capable of withstanding a factory test of a potential at least twice the line voltage applied continuously for a period of five minutes without breakdown between conductors or between any conductor

and the sheath or armor. The test voltage shall be applied between all conductors and between each conductor and the metal sheath or armor. The material and manufacture of the cable shall be such as to insure that the insulation of the cable will not be subject to serious deterioration in use.

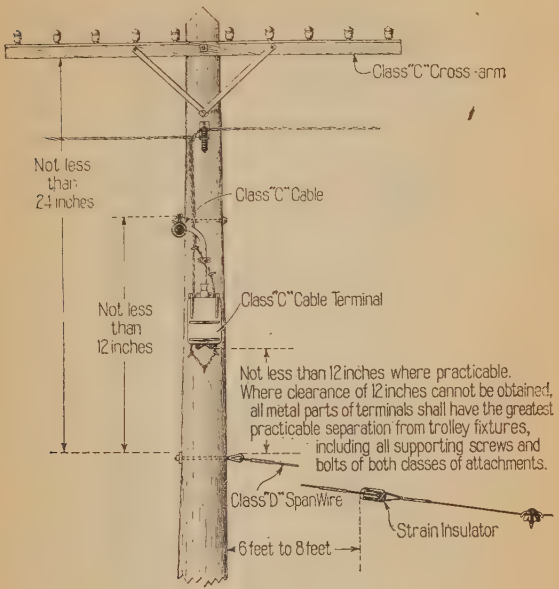

Class "C" Cross-arm
Not less than 24 inches
Class "C" Cable
Not less than 12 inches
Class "C" Cable Terminal
Not less than 12 inches where practicable. Where clearance of 12 inches cannot be obtained, all metal parts of terminals shall have the greatest practicable separation from trolley fixtures, including all supporting screws and bolts of both classes of attachments.
Class "D" Span Wire
Strain Insulator
6 feet to 8 feet

PLATE II
SHOWING TROLLEY SPAN WIRE CONSTRUCTION

(d) Splices in the cable shall be so made that the dielectric strength and durability at these points will not be materially less than that of the unspliced cable.

(e) Each section of cable between splices shall be suitably bonded to its suspension wire.

(f) The suspension wire shall be connected to well-made grounds at the ends of the jointly used section of line and at intermediate points not exceeding eight hundred feet apart. Where soil conditions are unfavorable for grounding, connections to ground

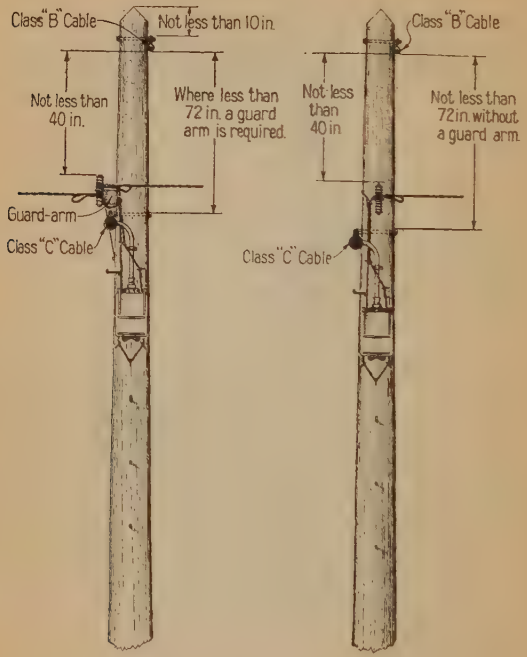

Class "B" Cable
Not less than 10 in.
Not less than 40 in.
Where less than 72 in. a guard arm is required.
Guard-arm
Class "C" Cable
Class "B" Cable
Not less than 40 in
Not less than 72 in. without a guard arm.
Class "C" Cable

PLATE 12
SHOWING CONSTRUCTION WITH CLASS "B" CABLE

should be made at more frequent intervals. The ground wires shall preferably be of copper not less than No. 4 A. W. G., but stranded steel wire of the same size as used for cable suspension may be used.

12. **General Requirements.** (a) The jointly used

line shall, so far as practicable, be kept free from trees which might fall into it.

(b) The poles shall, so far as practicable, be located away from inflammable material or structures.

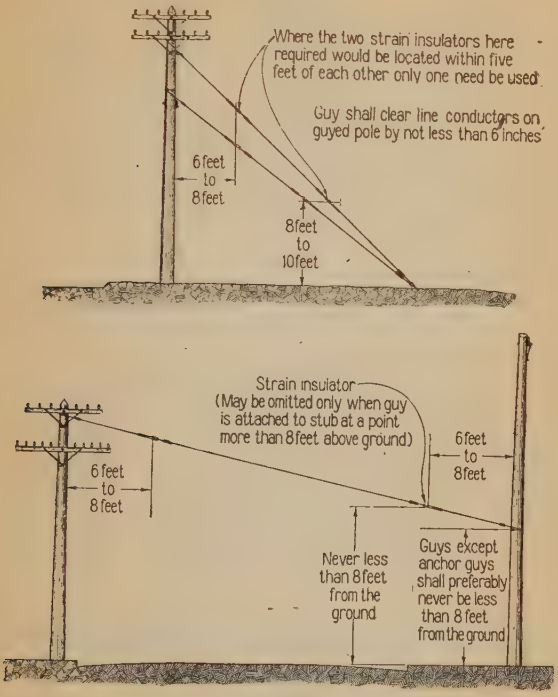

Where the two strain insulators here required would be located within five feet of each other only one need be used
Guy shall clear line conductors on guyed pole by not less than 6 inches
6 feet to 8 feet
8 feet to 10 feet
Strain insulator (May be omitted only when guy is attached to stub at a point more than 8 feet above ground)
6 feet to 8 feet
6 feet to 8 feet
Never less than 8 feet from the ground
Guys except anchor guys shall preferably never be less than 8 feet from the ground

PLATE 13
USE OF STRAIN INSULATORS IN GUYS

(c) Poles and guys exposed to excessive abrasion by traffic shall be protected by guards.

(d) All iron or steel hardware, including bolts, washers, guys, anchor rods and similar parts of material subject to injurious corrosion under the prevailing conditions, shall be protected by galvanizing, painting, or other treatment which will effectively retard corrosion.

(e) All features of construction not expressly covered by these specifications shall be in accordance with good modern practice.

Requirements for Grades A and B Construction—Loading

13. Loading for Determining Sags and Stresses in Line and Suspension Wires. In computing the sags corresponding to given limiting stresses in line wires, and suspension wires (Sections 18 and 23), the loading shall be assumed to be one of the following, according to climatic conditions of the locality concerned.

(a) Heavy Loading. The resultant loading at 0 degrees F., due to the weight of the wire, plus the weight of a layer of ice one-half inch in radial thickness, combined with a transverse horizontal wind pressure of eight pounds per square foot on the projected area of the ice-covered wire.

(b) Medium Loading. The resultant loading at 15 degrees F., equal to two-thirds that specified in (a) above. In no case, however, shall medium loading be less than 25 per cent. in excess of the weight of the wire.

(c) Light Loading. The resultant loading at 30 degrees F., equal to two-thirds that specified in (b) above or four-ninths that of (a). In no case, however, shall light loading be less than 25 per cent. in excess of the weight of the wire.

14. Loading for Determining Transverse and Vertical Stresses in Supporting Structures. In computing the vertical and transverse stresses on poles and crossarms, the loading shall be assumed to be one of the following, according to climatic conditions of the locality concerned:

(a) Heavy Loading. The following horizontal wind pressure at right angles to the direction of the line shall be considered as acting upon the poles and wires, the pressure being computed for the poles without ice covering while the line wires, cables and suspension wires are assumed to be covered with a layer of ice one-half inch in radial thickness.

Grade of Construction	Wind Pressure for Projected Areas For Cylindrical Surfaces	For Flat Surfaces.
A	12 lbs. per sq. ft.	19.2 lbs. per sq. ft.
B	7 lbs. per sq. ft.	11.2 lbs. per sq. ft.

In calculating the loads on the supporting structures, all wires and cables supported shall be included, except

that the calculation shall include only one-half the total number of signal wires smaller than No. 8 Stl. W. G. if steel or No. 6 A. W. G. if copper.

The vertical loading on crossarms shall be taken as their own weight, plus the weight of the wires supported plus the weight of a layer of ice one-half inch in radial thickness on each wire.

(b) Medium Loading. The transverse loading shall be taken as two-thirds of that specified in (a) above for heavy loading.

The vertical loading on crossarms shall be taken as their own weight plus the weight of the wires supported, plus the weight of a layer of ice one-quarter inch in radial thickness on each wire.

(c) Light Loading. The transverse loading shall be taken as two-thirds of that specified in (b) above or four-ninths that of (a).

The vertical loading on crossarms shall be taken as their own weight plus the weight of the wires supported, without ice covering.

15. **Weight of Ice.** In computing the sags and stresses in line wires and the vertical loading on crossarms the weight of ice shall be taken as fifty-seven pounds per cubic foot (0.033 pounds per cubic inch).

16. **Regions of Loading.** Heavy, medium, and light loading, respectively, are considered to be justified by weather reports as to wind and ice and by the local experience of the utilities using overhead lines. The classification of loadings should apply except in cases where the parties concerned agree to a modification of the same, based on local experience.

Line Wires

17. **Material and Size.** The minimum allowable sizes of line wires are given in the following table:

MINIMUM ALLOWABLE SIZES A. W. G.

Loading	Grade of Construction	Span Length Not Exceeding 150 ft.	175 ft.	200 ft.	250 ft.
Medium or hard drawn copper or copper-covered steel.					
Heavy	A & B	6	4	4	4
Medium	A & B	6	6	4	4
Light	A & B	6	6	6	6
Soft copper					
Heavy	A	4	2	1	—
	B	4	2	2	—
Medium	A & B	4	4	2	1
Light	A & B	6	4	4	2
Aluminum (without steel reinforcement)					
Heavy	A & B	1	0	0	0
Medium	A & B	1	0	0	0
Light	A & B	1	0	0	0

Line wires of steel reinforced aluminum or bronze of a strength not less than that of the specified sizes for hard drawn copper may be used.

No iron or steel line wires shall be used except in regions where experience has shown that iron or steel is not subject to serious corrosion and where so used shall be galvanized, and shall be not less than the following minimum sizes Stl. W. G.

Loading	Grade of Construction	Span Length Not Exceeding 150 ft.	175 ft.	200 ft.	250 ft.
Heavy	A & B	6	6	4	4
Medium	A & B	6	6	4	4
Light	A & B	6	6	4	4

All aluminum line wires shall be stranded and all iron and steel line wires preferably shall be stranded.

18. **Sags.** Sags for copper line wires are given in the tables in Appendix A. Less sags than those listed may be used if pins, fastenings, crossarms and poles of sufficient strength to withstand the corresponding increase in longitudinal stresses are used, but no sag shall be so decreased from the tabulated values that under the maximum assumed loading (Section 13) the tension will exceed 50 per cent. of the strength of the wire concerned.

For wires of other materials or sizes, or for different span lengths the sags shall be such that under the maximum assumed loading (Section 13), the tension will not exceed 50 per cent. of the breaking strength of the wires.

19. **Splices and Taps.** Splices and taps shall be avoided as far as practicable. If a splice or tap is necessary in any line wire it shall be so made as not to materially reduce the strength of the wire.

20. **Lightning Protection Wires.** Lightning protection wires shall be regarded as supply wires of the voltage in connection with which they are used in respect to size, material and sag, provided, however, that they may be of iron or steel of a size not less than five-sixteenths inch strand, except in locations where corrosion of iron or steel is unusually severe.

Suspension Wires

21. **Material.** Suspension wires shall be stranded and shall be of galvanized or copper-covered steel.

22. **Size.** Suspension wires shall be of not less than the following sizes:

Weight of Cable per Foot	Suspension Wire (ultimate tensile strength)
Less than 2.25 pounds	6,000 pounds
2.25 to 4.95 pounds	11,500 pounds
4.95 to 9.5 pounds	18,000 pounds

For cables weighing more than 9.5 pounds per foot, a correspondingly stronger method of suspension shall be used.

23. **Sag.** Suspension wires shall be strung with at least such sags that when they are supporting the cables and are subjected to the assumed loading (Section 13), the tension will not exceed 50 per cent. of their breaking strength.

24. **Supporting Fixtures for Cable Suspension Wires.** The clamps and through bolts used for fastening the suspension wires to the poles shall be capable of supporting the suspension wires and cable under maximum loading (Section 13), without the stresses in these fastenings exceeding 50 per cent. of the ultimate strength of the material. In the case of heavy cables, suitable reinforcing straps shall be used to prevent the stresses in the through bolts from exceeding the allowable limits. Rings or hangers for holding the cable to the suspension wires shall be of proper material and size to hold the cables to the suspension wires under the maximum conditions of loading without stressing the material beyond 50 per cent. of its breaking strength.

Insulators

25. **Material.** Insulators for supply circuits shall be of porcelain or other material which will give equally good results in respect to mechanical and electrical performance and durability.

26. **Design.** Insulators shall be so designed that their dry flash-over voltage is not more than 75 per cent. of their puncture voltage at a frequency of sixty cycles.

27. **Flash-over Voltage.** Insulators shall be capable of withstanding without flash-over, at a frequency of sixty cycles, voltages not less than those shown in the following table:

Voltage of Circuit	Flash-over Voltage Dry	Wet
6,600	40,000	30,000
7,500	45,000	33,000
11,000	60,000	45,000
22,000	110,000	83,000

Fon intermediate voltages obtain flash-over voltages by interpolation; for higher voltages by special agreement.

By the term "wet" is meant a condition equivalent to a precipitation of one-fifth inch of rain per minute at an angle of forty-five degrees to the axis of the insulator.

28. Tests. Each completed pin-type insulator for line voltages over 15,000 and each completed suspension insulator unit shall be subjected to a routine factory test at a frequency of sixty cycles, or any other test generally sanctioned by good modern practice.

29. Extra Insulation. Where strain type insulators are used at angles and other points in the line and pin-type insulators are used on the other portions of the line, such strain insulators shall be capable of withstanding a voltage 25 per cent. greater than the pin insulators.

Pins and Wire Fastenings

30. Strength. (a) Pins, ties, and other wire fastenings shall have sufficient strength to withstand the unbalanced tension in the line wires up to a limit of seven hundred pounds per pin or fastening. The height of the pins and wire fastenings and the material and cross-section of the pins shall be so chosen as to afford the required strength.

(b) The pins, ties, and other wire fastenings at angles and dead-ends, shall be constructed to withstand a longitudinal stress equivalent to the unbalanced pull, in one direction, of the wires supported, the pull being taken as the tension in the wires due to the loading specified in Section 13. Double crossarms with double pins and insulators should generally be used to meet this requirement.

(3) The requirements of (b) above shall also apply at the ends of jointly used sections of line if the grade of construction changes at these points.

Crossarms

31. Material and Size. Crossarms, if of selected yellow pine or fir, shall have dimensions not less than the following:

Number of Pins Carried	Dimensions of Cross Sections
2 or 4	3 x 4 inches
6 or 8	3¼ x 4¼ inches

If of other material, crossarms shall be the equivalent in strength and durability of the above.

32. Strength. (a) Crossarms when installed shall be capable of withstanding the vertical loads specified in Section 14 without the stress under these loads exceeding 50 per cent. of the assumed ultimate strength of the material.

(b) The crossarms at angles and dead-ends shall be constructed to withstand a longitudinal stress equivalent to the combined unbalanced pull of the wires sup-

ported, the pull being taken as the tension in the wires due to the loading specified in Section 13. Double crossarms should generally be used to meet this requirement.

(c) The requirements of (b) above shall also apply at the ends of jointly used sections of line if the grade of construction changes at these points, except that where the combined pull of the wires on a crossarm exceeds 10,000 pounds, the crossarm shall be able to withstand a pull of 10,000 pounds plus one-half the excess above 10,000 pounds for Grade A and plus one-quarter the excess for Grade B.

(d) Crossarms shall be securely supported, by bracing, if necessary, so as safely to withstand all other loads to which they may be subjected in use, including linemen working on them. In general they shall be maintained at right angles to the axis of the pole and to the direction of the attached wires.

POLES

33. Material and Size. Poles shall be of selected timber, free from defects which would decrease their strength and durability and shall have nominal top diamters not less than seven inches for Grade A in regions of heavy or medium loading and six inches for Grade A in regions of light loading or for Grade B in all regions of loading.

34. Strength. (a) Wood poles, and their foundations shall, when installed, be of such material and dimensions as will withstand the loading specified in Section 14, without the stresses under these loads exceeding 50 per cent. of the assumed ultimate strengths of the materials.

(b) With lines carried on wood poles of not less than eight inches top diameter where a larger number of wires is required than is permitted by (a) above, the initial pole stress under the above loadings may be increased to 75 per cent. of the assumed ultimate strength of the material if poles are especially selected "clear" strength requirements for structures, guys together wood poles and are maintained by systematic inspection and treatment or repairs to not less than three-fourths of their required strength when new.

(c) The poles at angles and dead-ends shall be constructed to withstand a longitudinal stress equivalent to the combined unbalanced pull of all the wires and cables supported, the pull of each wire being taken as the tension therein due to the loading specified in Section 13.

(d) The requirements of (c) above shall also apply at the ends of jointly used sections of line if the grade of construction changes at these points, except that where such combined pull exceeds 10,000 pounds the poles shall be able to withstand a pull of 10,000 pounds plus one-half the excess above 10,000 pounds for Grade A and plus one-quarter the excess for Grade B.

(e) When guys are used to meet the requirements of (a), (b), (c) or (d) above they shall be considered as taking the entire stress in the direction in which they act, the poles acting merely as struts.

Maintenance

35. Maintenance of Wood Poles and Crossarms. Wood poles and crossarms shall be replaced or reinforced when their strength has decreased to two-thirds that required by Rules 32 (a) and 34 (a) and (b) for new installations.

Guys

36. Material. Guys shall be stranded and shall be of galvanized steel or copper-covered steel.

37. Strength. When used in meeting transverse strength requirements for structures guys together with their guy rods and anchors shall be so installed that the stresses will not exceed 50 per cent. of the ultimate strength of the material under the specified loading.

38. Attachment to Anchors and Poles. (a) Guys to ground shall be connected to a well-anchored galvanized rod of such length that the eye of the rod shall be above the surface of the ground. Where attached to the anchor rods guys shall be protected by suitable thimbles.

(b) Where guys having a strength of 10,000 pounds or more are used on cedar or other soft wood poles, the poles shall in general be protected by the use of suitable strain plates or guy shims, and in this case guy hooks or other suitable means shall be provided to prevent the guys from slipping along the poles. Guy hooks shall also be used wherever the horizontal distance from anchor to pole is less than two-thirds the vertical height of the guy attachment to the pole above the anchor.

39. Guy Insulators. Strain insulators used in guys shall have a mechanical strength at least equal to that of the guys in which they are installed. They shall be permanently effective against the highest voltage to which the guys are exposed. Where exposed to voltages exceeding 15,000, the strain insulators may

be omitted if the guy is permanently and effectively grounded.

Modifications of Transverse and Longitudinal Strength Requirements in Special Cases

40. **Modification of Transverse Strength Requirements.** In cases where the requirements of Section 34 (a) for transverse strength of poles cannot be met except by the use of side guys or special structures which it is physically impracticable to employ, then the requirements for transverse strength will be considered to be met by side guying the line at each side of, and as near as practicable to, the transversely weak support, but with a distance between such side-guyed supports of not over eight hundred feet, provided:

(1) The side-guyed supports for each such section of eight hundred feet or less shall be designed to withstand the stress due to the transverse loading specified in Section 14, on the assumption that the whole transverse load on the line between the supports so side-guyed is carried by such side-guyed supports.

(2) The line between such side-guyed supports shall be substantially straight and the average length of spans shall not exceed one hundred and fifty feet.

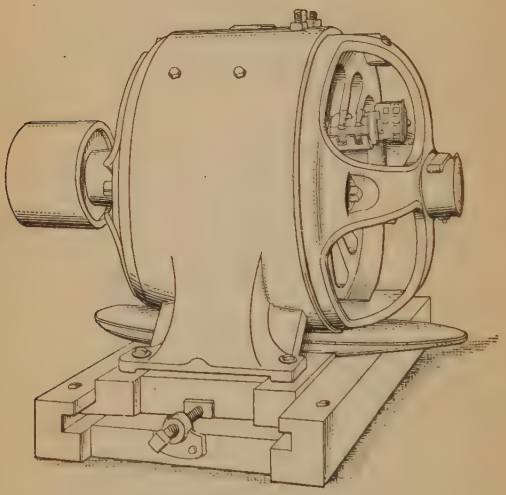
(3) The side-guyed supports, including their crossarms, insulator pins and wire fastenings shall be designed and constructed to withstand a longitudinal stress equivalent to the combined unbalanced pull in the direction of the transversely weak section of all the wires and cables supported, the pull of each wire being taken as the tension therein due to the loading specified in Section 13. If the transversely strong structure is not at an angle or dead-end and such combined pull exceeds 10,000 pounds the poles and crossarms shall be able to withstand a pull of 10,000 pounds plus one-half the excess above 10,000 pounds for Grade A, and plus one-quarter the excess for Grade B.

(4) The requirements of these specifications, except as modified in this section, shall be met throughout the section of line between the side-guyed supports.

GENERATORS

All generators, whether in central stations, substations, private or isolated plants, should be located in dry and well-ventilated rooms.

A precaution which has saved many generators from injury is the providing of each with its own waterproof cover, which should always be placed over the machine



Proper installation of dynamo or motor on filled wooden base frame when impracticable to ground the frame.

when not in operation. The accidental dripping of water or the accumulation of gritty dust on idle generators is likely to impair the windings of field or armature coils resulting in a burn-out when the generator is started.

Generators should never be placed in a room where any hazardous process is carried on, nor in places where they would be exposed to inflammable gases or flyings of combustible materials, as explosions and consequent fires may result.

All generators, when operating at a potential in

excess of 550 volts, should have their frames grounded as provided in the section on Grounding (page 101).

When operating at a potential of 550 volts or less, they should also have their frames grounded when practicable. When this is impracticable special permission in writing may be given for omitting the ground connection, in which case the frame should be permanently and effectively insulated. Wooden base frames (see illustration on page 302) used for this purpose and wooden floors which are depended upon for insulation where for any reason it is necessary to omit the base frames should be kept filled by several coats of shellac, varnish or other insulating compound to prevent absorption of moisture and be kept clean and dry.

Constant potential generators, except alternating current machines and their exciters, should be protected from excessive current by safety fuses or automatic circuit breakers (see page 19) of approved design.

For two-wire direct current generators, single pole protection is sufficient provided the safety device is so located and connected that the means for opening same is actuated by the entire generator current, and such a device will completely open the generator circuit.

If a generator not electrically driven supplies a two-wire grounded system, the safety device or devices should be so placed as to disconnect the generator from all conductors of the circuit.

For two-wire direct current generators used in conjunction with balancer sets to obtain a neutral for excessive unbalancing of voltages will operate to dis- three-wire systems (see diagram on page 313), a protective device should be installed, which in case of the connect the three-wire system.

For three-wire direct current generators, compound or shunt wound, a safety device should be placed in each armature lead, and so connected as to receive the entire current from the armature. Fuses should not be used in this connection. The safety device should consist of either a double pole, double coil, overload circuit breaker, or a four-pole circuit breaker connected in the main and equalizer leads, and tripped by means of two overload devices, one in each armature lead.

The safety devices above suggested should be so interlocked that no one pole can be opened without simultaneously disconnecting both sides of the armature from the system.

Every generator should be provided with a name-plate, giving the maker's name, the rating in kilowatts for D. C., KVA for A. C., the normal volts and amperes corresponding to this rating, also the speed in revolutions per minute.

Terminal blocks when used on generators should be made of approved non-combustible, non-absorp-tive insulating material, such as slate, marble or porcelain.

The use of soft rubber bushings to protect the lead wires coming through the frames of generators is permitted, except when installed where oils, grease, oily vapors or other substances known to have rapid deleterious effect on rubber are present in such quantities and in such proximity to generator as may cause such bushings to be liable to rapid destruction. In such cases porcelain or micanite bushings should be used.

Conductors. From generators to switchboards, rheostats or other instruments, and thence to outside lines conductors should be exposed to view and supported on approved non-combustible, non-absorptive insulators or placed in approved metal conduit (see page 151), tile or other fireproof ducts. Conductors installed in conduit or ducts where exposed to moisture should be lead sheathed and the sheathing grounded. Except for low potential systems the insulation of the several conductors where leaving the metal sheath of cables should be thoroughly protected from moisture and mechanical injury by means of a pothead (see illustration, page 252), or some equivalent method and have an approved insulating covering. Where conductors are closely grouped, as on switchboards, in wire towers, cableways, etc., the conductors should each have, in addition, a substantial flameproof outer covering. Bus-bars, if rigidly mounted, may be made of bare metal.

Flameproofing should be stripped back on all conductors a sufficient distance from the terminals to give the necessary insulation for the voltage of the circuit on which the conductor is used.

All such conductors when not installed in conduit should be kept so rigidly in place that they cannot come in contact. Where they pass through floors or fire walls they should be carried through individual openings in non-combustible, non-absorptive insulating tubes or their equivalent and not through a common open space.

In all other respects they should be installed with the same precautions as suggested in the section on Inside Wiring for wires carrying a current of the same volume and potential.

In wiring switchboards the ground detector, voltmeter, pilot lights and potential transformers should be connected to a circuit of not less than No. 14 B. & S. gage wire that is protected by approved fuses. This circuit should not carry over 660 watts.

For the protection of instruments and pilot lights on switchboards, **approved** N. E. Code Standard Enclosed Fuses are recommended (see pages 163 to 164), but **approved** enclosed fuses of other designs of **not over two amperes capacity** may be used.

All conductors should be so placed as to reduce to a minimum the danger of communicating fire to adjacent combustible material.

Switchboards should not be built up to the ceiling, a space of three feet being left, if possible, between the ceiling and the board. The space back of the board should be kept clear of rubbish and should not be used for storage.

All switchboards should be made of non-combustible material and be accessible from all sides when the connections are on the back, but may be placed against a brick or stone wall when the wiring is entirely on the face.

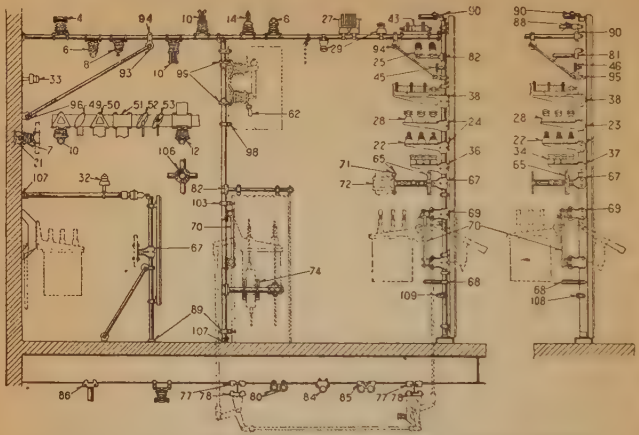
If the wiring is on the back of the switchboard there should be a clear space of at least eighteen inches between the wall and the apparatus on the board, and even if the wiring is entirely on the face, it is much better to have the board set out from the wall and kept free from moisture.

Insulated conductors where closely grouped as in rear of switchboards should each have a substantial flameproof outer covering.

Flameproofing should always be stripped back on all conductors a sufficient distance from the terminals to give the necessary insulation for the voltage of the circuit on which the conductor is used.

Resistance Devices. All resistance devices, such as rheostats and controllers, should be placed on a switchboard, or at a distance of at least one foot from combustible material, or separated therefrom by a slab or panel of non-combustible, non-absorptive insulating material such as slate, soapstone or marble somewhat larger than the rheostat, which should be secured in position independently of the rheostat supports (see

Westinghouse Switchboard Details



4 Bus Support with corrugated insulator
6 Bus Support with corrugated insulator
7 Bus Support with corrugated insulator
8 Bus Support with corrugated insulator
10 Bus Support with corrugated insulator
12 Bus Support with corrugated insulator
14 Bus Support with corrugated insulator
21 Insulator, Corrugated Porcelain
22 Bus-Strap Support
23 Bus-Bar Bracket
24 Bus-Bar Bracket
25 Bus-Strap Support
27 Bus-Strap Support
28 Bus-Rod Bracket and Supports
29 Bus-Rod Bracket and Supports
32 Bus-Rod Bracket and Supports
33 Bus-Rod Bracket and Supports
34 Insulator, Plain Porcelain
36 Bus-Rod Bracket and Supports
37 Bus-Rod Bracket and Supports
38 Bus-Rod Bracket
43 Bus-Rod Bracket
45 Bus-Wire Bracket
46 Bus-Wire Bracket
49 Bus-Bar Clamps
50 Bus-Bar Clamps
51 Bus-Bar Clamps
52 Bus-Bar Terminal
53 Bus-Bar Terminal
62 Terminal
65 Universal Auxiliary Bracket
67 Universal Mounting Bracket
68 Universal Mounting Strap
69 Universal Mounting Bracket
70 Mounting Bracket for Oil Circuit Breakers
71 Mounting Bracket for Current Transformers
72 Mounting Bracket for Current Transformers
74 Pipe Mounting Bracket
77 I-Beam Clamps
78 I-Beam Clamps
80 Pipe Conduit Clamps
81 Pipe Bracket
83 Pipe Saddle Clamps
84 Clamp
85 Clamp
88 Pipe End
89 Pipe End
90 Pipe Brace and Clamp
93 Wall Brace with Angular Adjustment
94 Wall Brace with Angular Adjustment
95 Wall Brace with Angular Adjustment
96 Wall Brace with Angular Adjustment
98 Barrier Bracket for Pipe Mounting
99 Mounting Clamp Bracket
103 Mounting Clamp Bracket
106 Pipe Cross Clamp
107 Pipe Flange Clamp
108 Mounting Clamp Bracket
109 Mounting Clamp Bracket

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illustration on page 334). Bolts for supporting the rheostat should be countersunk at least one-eighth inch below the surface at the back of the slab and the bolt heads covered with insulating material. For proper mechanical strength, the slab should be of a thickness consistent with the size and weight of the rheostat, and in no case should it be less than one-half inch.

If resistance devices are installed in rooms where dust or combustible flyings would be liable to accumulate on them, they should be equipped with dust-proof face plates.

Where protective resistances are necessary in connection with automatic rheostats, incandescent lamps may be used, provided that they do not carry or control the main current nor constitute the regulating resistance of the device.

When so used, lamps should be mounted in porcelain receptacles upon non-combustible supports, and should be so arranged that they cannot have impressed upon them a voltage greater than that for which they are rated. They should in all cases be provided with a name-plate, which should be permanently attached beside the porcelain receptacle or receptacles and stamped with the wattage and voltage of the lamp or lamps to be used in each receptacle.

Under special authorization in writing, given in advance by fire underwriters' inspectors, incandescent lamps may be used for the purpose of resistances in series with other devices when mounted in porcelain receptacles upon non-combustible supports and so arranged that they cannot have impressed upon them a voltage greater than that for which they are rated (see lamp table, page 366).

Wherever insulated wire is used for connections between resistance elements and the contact device of a rheostat, the insulation should be non-combustible, or "slow-burning" (see page 125). For large rheostats and similar resistances where the contact devices are not mounted upon them the connecting wires having "slow-burning" insulation may be so arranged in groups that the maximum difference of potential between any two wires in any group will not exceed seventy-five volts. Each group of wires should either be mounted on non-combustible, non-absorptive insulators giving at least one-half inch separation from surface wired over, or, especially where it is necssary to protect same from mechanical injury, each group of wires may be encased

in approved flexible tubing (see page 156), and placed in approved conduit (page 64), the flexible tubing to extend at least one inch beyond the ends of the conduit.

Lightning Arresters. An approved lightning arrester should be attached to each wire of every overhead circuit connected with the station and located in readily accessible places away from combustible materials, and as near as practicable to the point where the wires enter the building.

In all cases, kinks, coils and sharp bends in the wires between the arresters and the outdoor lines should be avoided as far as possible.

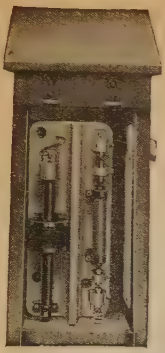
All lightning arresters should be well isolated from all other equipment, and if of the oil immersed type should be located outside or in a fireproof room or compartment on the premises and should be grounded as suggested in the section on Grounding, pages 101 to 108.

All choke coils or other attachments inherent to the lightning protection equipment should have an insulation from the ground or other conductors equal at least to the insulation demanded at other points of the circuit in the station.

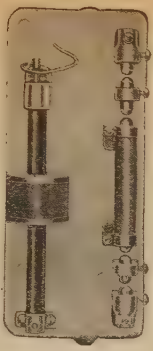
Ground Detectors. All circuits except such as are permanently grounded should be provided with reliable ground detectors. Detectors which indicate continuously and give an instant and permanent indication of a ground are preferable. Ground connection should be made in accordance with the suggestions on Grounding, pages 101 to 108).

Feeder Protection. Each constant potential circuit entering or leaving a supply station, except grounded rail return conductors of railway power plants or grounded neutral conductors of three-wire systems, should be protected from excessive current by an approved automatic overload circuit-breaker or by an equivalent device of approved design. Such protective devices should be located as near as practicable to point where conductors enter or leave the building. For outgoing circuits not connected with other sources of power, however, the protective devices may be placed on the supply side of transformers or similar devices.

Oil circuit-breakers and switches should be isolated from other switches and electrical apparatus. On circuits of over 7,500 volts they should be of the remote control type and be enclosed in separate fireproof cells or compartments.



Garton-Daniels
Pole Type Arrester



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Garton-Daniels Lightning Arresters have for more than a quarter century proven their efficiency and reliability in properly protecting electrical apparatus under the most severe conditions. All of your important apparatus should be protected by them.

Expulsion Type Lightning Arresters fill the demand for an inexpensive arrester particularly designed for the protection of the average line transformer; an arrester that is self-contained, that is easy to install and inspect, that is small enough to be installed directly on the transformer pole without crowding and that will give efficient lightning protection.

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Transformers. In central or sub-stations the transformers should be so placed that fire and smoke from the burning out of the coils or the boiling over of the oil (where oil-filled cases are used) can do no harm.

For oil-cooled transformers used in stepping voltage up or down before distribution, this will usually require a separate fireproof building, room or compartment cut off from the plant proper, provided with not less than six-inch non-combustible sill at doorway and with floor drained to some convenient point outside the building. Transformers of the air-cooled type should be isolated from all other equipment, and if of air-blast type should be supplied with air through fireproof ducts.

In central and sub-stations, casings of transformers should be grounded as given in the section on Grounding, pages 101 to 108.

The cases or frames of transformers used exclusively to supply current to switchboard instruments should also be grounded unless they are installed and guarded in all respects as required for the higher voltage circuit connected to them.

No transformer should ever be placed on the walls of buildings to which it furnishes current unless special permission is given, in writing, by the local authorities. Always, when possible, install transformers on poles, away from the building to be wired, as shown in cut on page 283.

Grounding of Low-Voltage Transformer Winding. Every effort is made in insulating transformers to guard against any chance of breakdown between high-voltage and low-voltage windings but, in order to be absolutely safe, it is advisable that low-voltage circuits with which persons may come in contact be grounded. The maximum voltage that can be obtained to ground is then limited to the normal voltage that exists between the grounded point and the line. This is true even if the high-tension and the low-tension windings become connected electrically.

In grounding the winding, the neutral point should be used if it is available.

When transformers operate on single-phase circuits with the middle point of the low-voltage winding grounded, the maximum voltage that can exist between any part of the low-voltage circuit and ground is one-half of the low-tension voltage.

Parallel Operation of Transformers. Transformers built to the same manufacturing specification, as indi-

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cated by the name-plates, may be operated in parallel.

Transformers built to different specifications should not be operated in parallel except under specific instructions from the manufacturer.

In connecting transformers in parallel when the low-tension voltage is comparatively low, care should be taken to see that corresponding connecting bars or conductors have approximately the same resistance; otherwise the currents will not divide equally.

Fire Extinguishers. At least one, or more, if the size of the installation demands it, good approved extinguisher should be in plain sight and readily accessible—one which is capable of extinguishing electrical fires or arcs without danger of transmitting a shock to the operator.

Oily Waste should be kept in approved metal cans (made entirely of metal, with legs raising them at least three inches above the floor, and with self-closing covers) and should be removed daily.

Attendance. A competent man should always be kept on duty where generators are operating.

DIRECT CURRENT GENERATORS

General Information, Connections, Operation and Care

Output. The output of a generator in watts may be obtained by multiplying the current in amperes by the e.m.f. in volts. To obtain the electrical horse power, the product obtained in the first operation is divided by 746.

$$\text{Elec. Horsepower} = \frac{\text{Volts} \times \text{Amperes}}{746.}$$

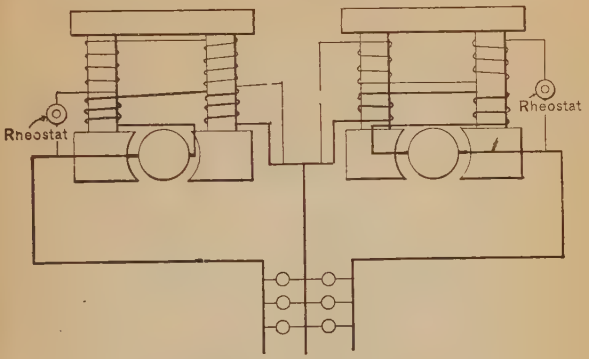
Windings. Depending upon the character of field winding employed, direct-current generators and motors are classified under one of the following three groups:

1. Shunt wound.
2. Series wound.
3. Compound wound.

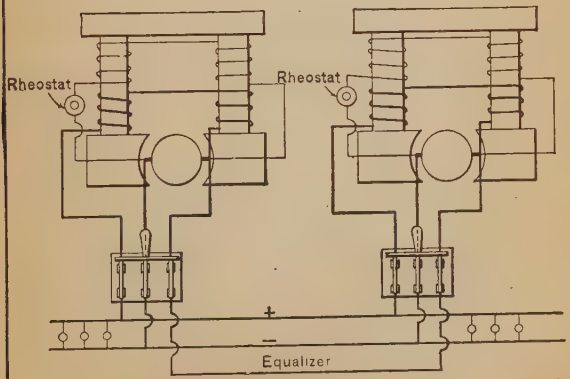
See diagrams, pages 313 and 315.

Shunt-Wound Generator. The field winding of a shunt-wound generator is composed of a large number of turns of wire or strap of comparatively high resistance, which is connected directly to the armature terminals, forming, in parallel with the main circuit, a

CONNECTIONS FOR DIRECT CURRENT DYNAMOS.



THREE WIRE DISTRIBUTION



MULTIPLE DISTRIBUTION-TWO WIRE

shunt circuit through which only a small percentage of the total current flows.

The regulation characteristic of a shunt-wound machine is such that the voltage is a maximum at no load, and drops as the load increases unless regulated by the manipulation of a rheostat in the field circuit.

Series-Wound Generator. The field winding of a series-wound generator is composed of a heavy wire or strap connected in series with the armature and external circuit. With this type of machine the total current delivered flows through the field winding and the voltage varies directly with the load. The greater the load the higher the voltage. Generally, a slight load is required to make these machines pick up voltage.

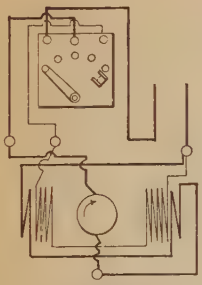
Compound-Wound Generator. A compound-wound machine has both shunt and series winding. It may be generally assumed that the shunt field is so designed that on open circuit, the series field being idle, the machine will generate the desired line voltage. The result of applying load would, as noted under "Shunt Generator," tend to lower the terminal voltage; but it is here that the utility of the compound winding becomes apparent. The series coils reinforce the shunt field in direct proportion to the increase of load and thus hold the terminal voltage constant, balancing the drop due to increased copper loss and armature reaction at the heavier loads.

It is a difficult matter to design a machine for exact voltage under all conditions and for this reason additional hand regulation is provided in the form of a rheostat in the shunt-field circuit.

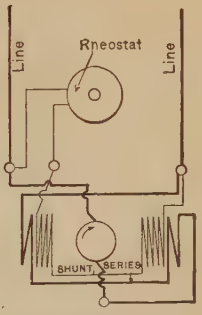
It is easily possible and quite generally desirable to have a compound-wound generator over-compounded, i. e., provided with a series field of sufficient strength to not only hold the voltage constant but increase it with increase of load. The over-compounding is customarily given as the percentage of the no-load terminal voltage which the increase in voltage from no load to full load represents. Thus a 9 per cent. over-compounded 230-volt generator will have a full-load voltage of approximately 250.

Connections for Parallel Operation. Parallel operation of direct-current generators is effected in a comparatively easy manner if machines are of the same make and voltage or are designed with similar electrical characteristics. If they are shunt-wound machines, no connections other than main leads are required as the

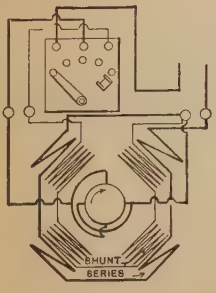
CONNECTIONS FOR DIRECT CURRENT MOTORS & DYNAMOS



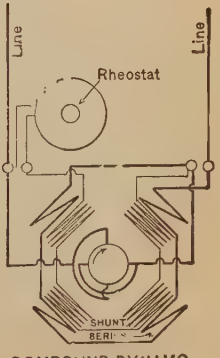
COMPOUND MOTOR
2-POLE



COMPOUND DYNAMO
2-POLE



COMPOUND MOTOR
4-POLE



COMPOUND DYNAMO
4-POLE

inherent regulation characteristics are such as to insure proper division of the load. If they are compound-wound machines, the addition of equalizer connections between the machine is required. See diagram page 313. If the generators have different compounding ratios, it will be necessary to change adjustments so that all machines have the same inherent regulation; i. e., with shunt field adjusted by rheostat for same voltage as no load, the compounding is such as to produce the same voltage on all at full load. The way to determine if all machines have the same regulation is to test them individually.

Equalizer. An equalizer, or equalizer connection, connects two or more generators operating in parallel at a point where the armature and series field leads join, thus placing the armatures in multiple and the series in multiple, in order that the load may be divided between the generators in proportion to their capacities.

The object of the equalizer, as the name implies is to divide the total load between the machines according to their capacity. Consider, for example, two compound-wound machines operating in parallel without an equalizer. If, for some reason, there is a slight increase in speed of one machine, it would take more than its share of load; and the increased current flowing through the series field would strengthen the magnetism, raise the voltage, and cause the machine to take a still greater amount until it carried the entire load. When equalizers are used, the current flowing through each series coil is proportional to the resistance and is independent of the load on any machine; consequently an increase of voltage on one machine builds up the voltage of the other at the same time, so that the first machine cannot take all the load, but will continue to share it in proper proportion with the other generators.

OPERATION OF GENERATORS

General Rules—Leave all switches open when machine is not running.

At all times keep the generator clean and free from oil and dust, especially from copper or carbon dust. With high-voltage machines a small accumulation of dust on the windings may be the cause of serious burn-out.

Keep small pieces of iron and bolts and tools away

from the frame. Any such fragment attracted to the pole of a field magnet may jam between the armature and pole and cause serious damage.

Occasionally give the machine a thorough inspection. The higher the voltage of the generator the oftener this should be done.

Starting Generators—See that the bearings are well supplied with oil and that the oil rings are free to turn. Inspect all connections for loose screws or wires.

Start slowly. See that the oil rings are revolving properly.

Turn in all resistance in the field rheostat, then bring the machine up to speed.

Adjust the rheostat for the normal voltage of the generator.

Throw on the load.

Causes of Insufficient Voltage—The following causes may prevent generators from developing their normal e. m. f. (electro motive force):

The speed of the generator may be below normal.

The switchboard instruments may be incorrect and the voltage may be lower than that indicated, or the current may be greater than is shown by the readings.

The series field may be reversed, or part of the shunt field reversed or short-circuited.

The brushes may be incorrectly set.

A part of the field rheostat or other unusual resistance may be in the field circuit.

Reversing Polarity—To change the polarity, if a generator keeps the same rotation, it is necessary to reverse the magnetism in the field circuit which is done by exciting the shunt field in the opposite direction.

Reversing Rotation—To change the rotation but not the polarity, it is necessary to reverse either the magnetism or the armature leads. The simplest method, and the one recommended, is to reverse the leads to the armature and the leads to the commutating-pole winding. In all commutating-pole machines, it must be borne in mind that the direction of current in the armature and commutating-pole windings always bear the same relation to each other, and, if the armature current is reversed for any reason, the commutating-pole coils must be reversed.

To Parallel—To throw a machine on the line in "parallel" with machines already operating:

Bring the machine up to normal speed.

With a voltmeter connected to its terminals gradually bring up the voltage by cutting out resistance in

the rheostat until approximately the voltage of the other machines is reached. Throw in equalizer switch. Adjust voltage, if necessary. Throw in main switches. Adjust rheostat till generator takes its proportion of the load. The proper voltage to obtain before throwing a generator in parallel with others can be found by trial. It may vary slightly from line voltage depending on local conditions, regulation, etc.

Excitation of D. C. Generators—When starting up, a generator may fail to excite itself. This may occur even when the generator operated perfectly during the preceding run. It will generally be found that this trouble is caused by a loose connection or break in the field circuit, by poor contact at the brushes due to a dirty commutator or perhaps by a fault in the rheostat, or incorrect position of brushes. Examine all connections; try a temporarily increased pressure on the brushes; look for a broken or burnt out resistance coil in the rheostat. An open circuit in the field winding may sometimes be traced with the aid of a magneto bell; but this is not an infallible test as some magnetos will not ring through a circuit of such high resistance as some field windings have even though intact. If no open circuit is found in the rheostat or in the field winding, the trouble is probably in the armature. But if it be found that nothing is wrong with the connections or the winding it may be necessary to excite the field from another generator or some other outside source.

A very simple means for getting a compound-wound machine to pick up is to short-circuit it through a fuse having approximately the current capacity of the generator. If sufficient current to melt this fuse is not generated, it is evident that there is something wrong with the armature, either a short-circuit or an open circuit. If, however, the fuse has blown, make one more attempt to get the machine to excite itself. If it does not pick up, it is evident that something is wrong with the shunt winding or connections.

If a new machine refuses to excite and the connections seem to be alright, reverse the connections, i. e., connect the wire which leads from the positive brush to the negative brush and the wire which leads from the negative brush to the positive brush. If this change of connections does no good, change back and locate the fault.

To Shut Down Generator—Reduce the load as much as possible by throwing in resistance with the field rheostat.

Throw off the load by opening the circuit-breaker, if one is used, otherwise open the feeder switches and finally the main generator switches.

Shut down the driving machine.

Wipe off all oil and dirt, clean the machine and put it in good order for the next run.

Opening of Feeder Circuits—If a line fuse blows or a circuit-breaker opens, first open the switch controlling that line, and then replace the fuse and close the breaker. The switch may now be closed again. If the circuit opens the second time, there is something wrong on the line—probably a short-circuit—and this should be corrected at once.

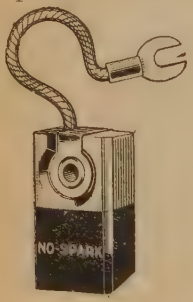
If for any reason, such as a short-circuit or a heavy overload on the line, the circuit-breaker or switches hold an arc when opened, such an arc should be extinguished if possible by using dry sand, a supply of which should always be kept conveniently at hand. In case the arc cannot be extinguished in this manner, as a last resort, open the field circuit of the machine or shut the generator down entirely. When the arc forms on the machine or on the generator side of the breakers, a shut-down is generally imperative, but should not be made if it can possibly be avoided. (See "Pyrene," p. 258.)

Brushes—The ends of all brushes should be fitted to the commutator so that they make good contact over their entire bearing face. This can be most easily accomplished after the brushholders have been adjusted and the brushes inserted. Lift a set of brushes sufficiently to permit a sheet of sandpaper to be inserted. Draw the sandpaper in the direction of rotation under the brushes releasing the pressure as the paper is drawn back being careful to keep the ends of the paper as close to the commutator surface as possible and thus avoid rounding the edges of the brushes. It will be found that by this means a satisfactory contact is quickly secured, each set of brushes being similarly treated in turn. If the brushes are copper plated, their edges should be slightly beveled, so that the copper does not come in contact with the commutator.

Commutator surface speeds of direct-current turbo-generators are somewhat higher than for standard machines of other types owing to their larger diameter. For this reason it is usually necessary to use a self-lubricating brush. Brushes in the market that have this characteristic are ordinarily of graphite nature and are weaker mechanically and hence more easily broken

NO-SPARK CARBON BRUSHES

You'll be proud of the appearance, condition and performance of your generator and motor commutators if you equip them with "No-Spark" Carbon Brushes.



These smooth-wearing brushes are practically frictionless and of the correct and even conductivity and hardness to meet the needs of the service specified.

They eliminate sparking, scoring and undue wear, insuring higher operating economy and fewer repairs.

Easily pay their own cost several times over each year in saving in repair bills alone.

They will not crumble, crack or break. In many cases they have outlasted three or four sets of ordinary brushes. Users are enthusiastic in their praise.

Made in many grades, styles and sizes to suit the characteristics of the various types of electrical machines.

Our engineers are at your service to insure the proper selection for your plant.

Let us prove our claims to you.
Write today for interesting bulletins.

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1503 Columbia Ave., Philadelphia, Pa.

than the carbon brushes for lower-speed machines. They are also softer, and reasonable care should be exercised in handling them when the machine is taken apart or assembled. Rough handling or carelessness will probably cause breakage.

With graphite brushes of good quality, no oil should be necessary for lubricating the commutator; and as a rule oil will have a tendency to "gum" the surfaces of the brushes, unless used very sparingly.

Besides maintaining the brushes in the proper position, the following points should be observed:

Make frequent inspection to see that—

Brushes are not sticking in holders.

Pig-tail shunts are properly attached to brushes and holders.

Tension is adjusted as brush wears.

Copper plating is cut back so it does not make contact with the commutator.

Worn-out brushes are replaced before they reach their limit of travel and break contact with the commutator.

Remove any free copper picked up by the face of the brush.

Commutator—The commutator is perhaps the most important feature of the whole machine in that it is most sensitive to abuse. Under normal conditions, it should require little attention beyond frequent inspection. The surface should always be kept smooth, and if, through extreme carelessness, neglect, or accident, it becomes badly roughened, the armature should be removed and the commutator turned down in an engine lathe. Sometimes with a large machine it is more convenient to rig up a temporary trueing device, leaving the armature in its own bearings and running it slowly either as a shunt motor or from a separate belted motor. Ordinarily, unless in very bad condition, it may be dressed down with a piece of sandstone conveniently mounted in a device especially designed for this purpose.

Sometimes a little sandpapering is all that is necessary. **Emery cloth or paper should never be used for this purpose** on account of the continued abrasive action of the emery which becomes embedded in the copper bars and brushes. Even when sandpaper is used the brushes should be raised and the commutator wiped clean with a piece of canvas lubricated with a very small quantity of vaseline or oil. Cotton waste

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Charles Farnham, I. W. Hellman Bldg., Los Angeles, Calif.
Railway & Power Engineering Corporation, Ltd., 131 Eastern Avenue, Toronto, Ontario, Canada

should never be used and an excess of lubricant must be avoided.

Under normal conditions the commutator should become dark and highly polished after a few weeks' operation, and so remain unchanged for years.

Trouble is sometimes experienced from the burning out of mica insulation between segments. This is most commonly caused by allowing the mica to become oil soaked or by the bars loosening and thus allowing foreign conducting material to work its way in between them. It is rarely, if ever, definitely traced to excessive voltage between bars. When this burning does occur it may be effectively stopped by scraping out the burned mica and filling the space with a solution of sodium silicate (water glass), or other suitable insulating cement.

Even with the most careful workmanship, high mica will sometimes develop and start sparking, which burns away the copper and aggravates the difficulty. By prompt action, serious damage can be prevented by cutting away the mica to a depth of one-thirty-second to one-sixteenth of an inch below the adjacent copper. A hack-saw blade held between suitable guides will serve the purpose of a cutter. Machines designed for slotting commutators are now obtainable.

Bearings—Most machines have self-oiling bearings. The well should be filled to such a height that the rings will carry sufficient oil upon the shaft. If the bearings are too full oil will be thrown out along the shaft. The oil should be renewed about once in six months, or oftener if it becomes dirty and causes the bearings to heat. Bearing housings are usually supplied with outlet holes for overflow of the oil. The oil should be kept slightly below the level of the holes.

The bearings must be kept clean and free from grit. They should be frequently examined to see that the oil supply is properly maintained and that the oil rings do not stick. Use only the best quality of oil. New oil should be run through a strainer if it appears to contain any foreign substance. If the oil is used a second time, it should first be filtered and, if warm, allowed to cool.

Belts—The belt on a belt-connected machine should be tight enough to run slowly without slipping, but the tension should not be too great or the bearings will heat. Belts should run with the inside lapping, not against it, and the joints should be dressed smooth so that there will be no jarring as it passes over the pul-

ley. The crowns of driving and driven pulleys should be alike as "wabbling" of belts is sometimes caused by pulleys having unlike crowns. If the wabbling is caused by bad joints, they should be broken and cemented over again. A wave motion or flapping is usually caused by slippage between the belt and pulley, resulting from grease spots, etc. It may, however, be a warning of an excessive overload. This fault may sometimes be corrected by increasing the tension, but a better remedy is to clean the belt. A back and forth movemen remedy is to clean the belt. A back and forth movement on the pulley is caused by unequal stretching of the edges of the belt. If this does not cure itself shortly examine the joints. If they are evenly made and remain so, the belt is bad and should be discarded. See formula for belting, page 405.

Sparking at the brushes may be due to any one of the following causes:

The machine may be overloaded.

The brushes may not be set exactly at the point of commutation. A position can always be found where there is no perceptible sparking, and at this point the brushes should be set and secured.

The brushes may be wedged in the holders or have reached the end of their travel.

The brushes may not be fitted to the circumference of the commutator.

The brushes may not bear on the commutator with sufficient pressure.

The brushes may be burnt on the ends.

The commutator may be rough; if so, it should be smoothed off with sandpaper, not emery cloth.

A commutator bar may be loose or may project above the others.

The commutator may be dirty, oily or worn out

The carbon brushes may be of an unsuitable grade.

The brushes may not be equally spaced around the periphery of the commutator.

Some brushes may have extra pressure and may be taking more than their share of the current.

High mica.

Vibration of the brushes.

These are the more common causes, but sparking may be due to an open circuit or loose connection in the armature. This trouble is indicated by a bright spark which appears to pass completely around the commutator, and may be recognized by the scarring of the commutator at the point of open circuit. If a

lead from the armature winding to the commutator becomes loose or broken it will draw a bright spark as the break passes the brush position. This trouble can be readily located, as the insulation on each side of the disconnected bar will be more or less pitted.

The commutator should run smoothly and true, with a dark, glossy surface.

Heating of Armature—Heating of the armature may develop from any of the following causes:

Too low speed.
Too high voltage.
Too great forward or backward lead of brushes.
Partial short-circuit of one coil.
Overload.

Heating of Armature—Heating of the armature may develop from any of the following causes:

Too great a load.
Short circuit in coils.
Grounds on armature or commutator.

Hot Box or warm bearing is probably due to one of the following causes:

Excessive belt tension.
Failure of the oil rings to revolve with the shaft.
Rough bearing surface.
Improper fitting of the journal boxes.
Bent shaft.
Use of poor grade or dirty oil.
Bolts in the bearing cap may be too tight.

End thrust, due to improper leveling. A bearing may become warm because of excessive pressure exerted by the shoulder of the shaft against the side of the bearing.

End thrust, due to the magnetic pull, rotating part being "sucked" into the field because it extends beyond the field poles further at one end than at the other.

Excessive side pull, because the rotating part is out of center.

If a bearing becomes hot, first feed heavy lubricant copiously, loosening the nuts on the bearing cap; and then, if the machine is belt-connected, slacken the belt. If relief is not afforded, shut down, keeping the machine running slowly until the shaft is cool, in order that the bearing may not "freeze." Renew the oil supply before starting again. A new machine should always be run at a slow speed for an hour or so in order to see that it operates properly. The bearings should be carefully watched to see that the oil rings are revolving and carry a plentiful supply of oil to the shaft.

MOTORS.

The Installation of Motors—All motors when operating at a potential in excess of 550 volts should have no exposed live metal parts, and have their base frames permanently and effectively grounded in accordance with the suggestions given in the section on Grounding, see pages 101 to 108.

When operating at a potential of 550 volts or less, their base frame should be permanently and effectively grounded wherever feasible. Where grounding of the frame is impracticable, special permission for its omission may be given, in writing, by the local insurance or city inspection department, in which case the frame should be permanently and effectively insulated. Wooden base frames used for this purpose and wooden floors which are depended upon for insulation where for any reason it is necessary to omit the base frames should be kept filled to prevent absorption of moisture and be kept clean and dry.

Motors operating at a potential of 550 volts or less should be wired with the same precautions as suggested in the section on Inside Wiring (see pages 3 to 115) for wires carrying a current of the same volume.

Motors operating at a potential between 550 and 3,500 volts should, except in central or sub-stations, be wired with approved multiple conductor, metal sheathed cable in approved metal conduit. All apparatus and wiring connected to the high tension circuit should be completely enclosed in substantial grounded metal shields or casings and the conduit should enter and be properly secured to such casings or to suitable terminal boxes screwed or bolted to the casings.

The insulation of the several conductors for high potential motors, where leaving the metal sheath of cables, should be thoroughly protected from moisture and mechanical injury. This may be accomplished by means of a pot head, see illustration on page 252 or some equivalent method. The conduit should be substantially bonded to the metal casings of all fittings and apparatus connected to the inside high tension circuit. Except where exposed to moisture a metal sheath need not be provided over splices, but the ends of the sheaths should be belled out and sheaths should be bonded around splices by No. 6 B. & S. gage copper wire and approved ground clamps.

AMONG

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Repulsion Start Induction

Single Phase Motors

1/10 to 1/4 H. P.

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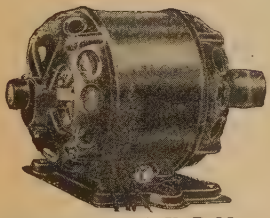

Illustrating a 1/6 H. P. Motor

HIGH STARTING TORQUE—

LOW STARTING CURRENT—

RING OILER BEARINGS—

A fuse which will protect while running is usually sufficient for starting

Other sizes up to 40 H. P.

CENTURY ELECTRIC COMPANY

ST. LOUIS, U. S. A.

Where outside conductors directly enter the motor room special permission in writing should be obtained to install the wires for high potential motors according to the general rules for high potential systems.

Conductors carrying the current of only one motor should be designed to carry a current at least 10 per cent. greater than that for which the motor is rated. Where the conductors would be overfused in order to provide for the starting current, as in the case of many of the alternating current motors, the conductors should be of such size as to be properly protected by these larger fuses.

To provide for the peak loads which are encountered in certain classes of service, such as those mentioned in the following table, without over-fusing the conductors, motors will sometimes require cables considerably larger than those specified in the preceding paragraph. In the majority of cases the necessary requirements will be met if conductors are based on the following percentages of the name plate rating:

Classification of Service	Percentages of Name-Plate Rating		
	5 min. rating.	10 min. rating	30 min. rating
Operating valves raising or lowering rolls	110	120	150
Rolling tables	110	120	135
Hoists, rolls, ore and coal-handling machines	110	115	120
Freight and passenger elevators, shop cranes, tool heads, pumps, etc.	110	110	110

Classification of Service	Percentages of Name-Plate Rating	
	2 hour rating	Continuous rating
Operating valves or lowering rolls	200	250
Rolling tables	180	200
Hoists, rolls, ore and coal-handling machines	150	170
Freight and passenger elevators, shop cranes, tool heads, pumps, etc.	120	140

Varying speed motors are motors in which the speed varies automatically with the load, decreasing when the load increases, and vice versa. It does not mean motors in which the speed is varied by the use of different windings or grouping of windings, or motors in which the speed is varied by external means, and in which, after adjusting to a certain speed, the speed remains practically constant.

Each motor with its starting device should be protected by a cut-out and controlled by a switch (see page 31), said switch plainly indicating whether "on"

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Motors Dynamos

For Direct and Alternating Current Service

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Motor-Generator Sets

Diehl Manufacturing Co.

ELIZABETH, N. J.

Boston, Chicago, New York, Philadelphia

or "off." Small motors may be grouped under the protection of a single set of fuses, provided the rated capacity of the fuses does not exceed 10 amperes and the total wattage of the circuit does not exceed 660. With motors of one-fourth horse power or less, on circuits where the voltage does not exceed 300, single pole switches may be used. The switch and rheostat should always be located, when practicable, within sight of the motor.

Where the circuit-breaking device on the motor-starting device disconnects all wires of the circuit the switch may be omitted.

Over-load-release devices on motor-starting devices will not be considered to take the place of the cut-out required for this class of work.

An automatic circuit-breaker disconnecting all wires of the circuit may serve as both switch and cut-out.

Where a rubber-covered conductor, see page 117, carries the current of only one A. C. motor of a type requiring large starting current, it may be protected by a fuse or an automatic circuit breaker without time limit device. The rated continous current capacity of a time limit circuit breaker protecting a motor of the above type need not be greater than 110% of the motor current rating, providing the time limit device is capable of preventing the breaker opening during the starting period.

In most cases where A. C. motors of the above type are started by means of autostarters the current-carrying capacity of wires meeting the rule will not exceed the following precentages of the full load currents of the motors.

Rated full load current	Percentage
0- 30 amperes	250
Above 30 amperes	200

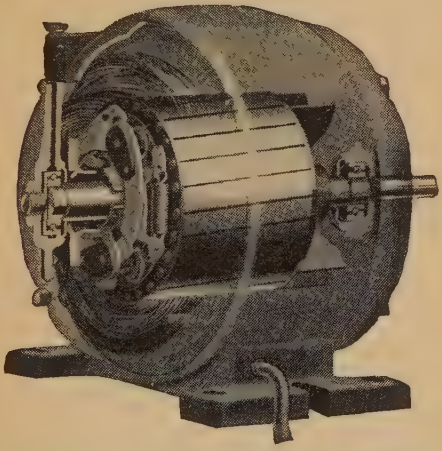
Rheostats should be so installed as to comply with all the suggestions on this subject.

Auto starters, unless equipped with tight casings enclosing all current-carrying parts, in all wet, dusty or linty places, should be enclosed in approved cut-out boxes or cabinets. Where there is any liability of short circuits across their exposed live parts being caused by accidental contacts, a railing should also be erected around them.

Motors should not be run in series-multiple or multiple-series, except on constant-potential systems.

DOMESTIC SMALL MOTORS

The Dependable Motor for Your Electric Driven Devices



Phantom view of Motor showing Ball Bearings

MANUFACTURERS OF SMALL MOTORS

Specialists in Small Motor Applications

THE DOMESTIC ELECTRIC COMPANY

CLEVELAND, OHIO

When deemed necessary, motors should be enclosed in approved cases.

Such enclosures should be readily accessible, dust proof and sufficiently ventilated to prevent an excessive rise of temperature. Where practicable the sides should be made largely of glass, so that the motor may be always plainly visible.

The use of an enclosed type motor is recommended in dusty places, being preferable to wooden boxing.

All motors permanently located on wooden floors should be provided with suitable drip pans.

When motors are combined with ceiling fans, they should be hung from insulated hooks, or else there should be an insulator interposed between the motor and its support.

Every motor should be provided with a name-plate, giving the maker's name, the capacity in volts and amperes, and the normal speed in revolutions per minute.

All varying (or variable) speed motors should be marked with the maximum current which they can safely carry for 30 minutes, starting cold.

Motor terminal blocks should be made of **approved** non-combustible, non-absorptive, insulating material such as slate, marble or porcelain.

Adjustable speed motors, if controlled by means of field regulation, should be so arranged and connected that they cannot be started under weakened field.

The use of soft rubber bushings to protect the lead wires coming through the frames of motors is permitted, except when installed where oils, grease, oily vapors or other substances known to have rapid deleterious effect on rubber are present in such quantities and in such proximity to motors as may cause such bushings to be liable to rapid destruction. In such cases porcelain or micanite bushings should be used.

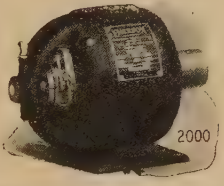
Starting and Stopping Motors (Direct Current Shunt Wound)—One rule at all times to be remembered in starting and stopping motors is, **switch first, rheostat last,** which means, in starting, **close the switch first,** and then gradually cut out all resistance as the motor speeds up. To stop the motor **open the switch first** and then cut in all resistance of the rheostat which is in series with the motor armature. When starting any new motor for the first time, see suggestions on pages 340 to 343. Never keep the rheostat handle on any of its coils longer than a moment, as they are not designed to regulate the speed of the motor, but to prevent too

Emerson Fans

The Fans with the
5-year factory-to-user guarantee

Emerson Motors

2 hp and smaller



Small Motors for every power purpose
Special Motors made for individual drives

Northwind Fans

High-grade low-priced universal fans
in standard packages, for
A.C.-D.C. circuits

Fan and Motor stocks maintained at
St. Louis and New York and by many jobbers.

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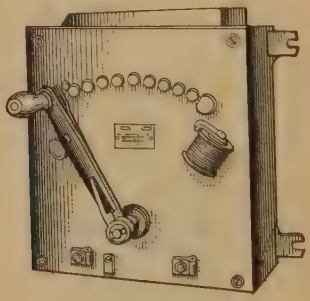
large a flow of current into the armature before the latter has attained its full speed.

The illustration above shows a rheostat which is designed to automatically protect the armature of a motor. The contact arm is fitted with a spring which constantly tends to throw the arm on the "off-point" and open the circuit, but is prevented from so doing, while the motor is in operation, by the small electromagnet, shown on the face of the rheostat, which consists of low resistance coil connected in series with the field winding of the motor. This magnet holds the contact arm of the rheostat in position, allowing the maximum working current to flow through the armature while it is in operation.



Motor Starting Rheostat or "Resistance Box" with No-Voltage Release. Slate front carries lever, contacts and retaining magnet, mounted on a ventilated box of pressed steel which serves as a container for the resistance.

If, for some reason or other, the current supplied to the motor be momentarily cut off, the speed of the armature generates a counter current which also tends to hold the arm in position as long as there is any motion to the motor armature, but as soon as the armature ceases to revolve all current ceases to flow through the electromagnet, thereby releasing the rheostat handle, which flies back to the "off" point, as shown in the illustration, and the motor armature is out of danger. Such a device is of great value where inexperienced men have to handle motors, and are unaware that the first thing to be done when a motor stops for any reason whatever is to open the circuit, and then cut in all the resistance in the rheostat to

Type T Heavy Duty RELIANCE MOTORS-

Direct Current

General Service Motors

Type T Reliance Motors are made for general use in all kinds of plants using direct current power. They are designed for both constant speed and adjustable speed duty. Speed adjustments over ranges up to 1 to 4 are obtained by field resistance control.

How the practical experience of 35 electrical engineers in the large steel mills and machine shops was built into Type T motors is an interesting story for motor users. It is told and illustrated in Bulletin 2014.

Reliance Electric & Engineering Co.
1058 Ivanhoe Road, Cleveland, Ohio

Branches: New York
Philadelphia, Pittsburgh,
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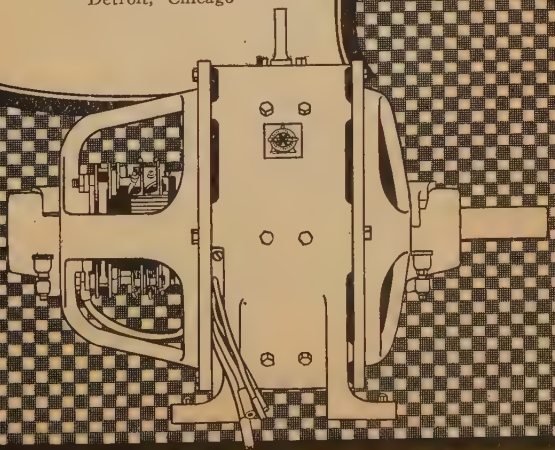


prevent too large an in-rush of current when the motor is started up again.

The overload circuit breaker is also a most valuable protection for motors.

Motor Wiring Formulae—(Direct Current)—To find the proper size of wire for direct-current motors proceed as follows:

E = voltage of motor.
D = single distance from generator to motor in feet.
V = Volts loss in lines.
K = efficiency of motor (see table below).
10.8 = resistance in ohms of a wire one foot long and .001 inch diameter.
C.M. = circular mils, or cross section of conductor.

$$\text{Then C.M.} \quad \frac{\text{horsepower} \times 746 \times 2d + 10.8}{e \times v \times k}$$

or simplified

$$\text{C.M.} \quad \frac{\text{horsepower} \times d \times 16113.6}{e \times v \times k}$$

Compare the size of wire thus found with that allowed by the Underwriters for full load current of motor, + 10%. If the former be smaller it must be increased to the latter figure to be approved and the resulting lower line loss accepted (see Table, page 17).

The Average Motor Efficiency (K).

1 h.p. and under.....75 per cent.
3 h.pp to 5 h.p.....80 per cent.
5 h.p. to 10h.p.....85 to 90 per cent.
Over 10 h.p.....90 per cent.

The tables and examples worked out on pages 6 to 14 will give the desired results, in many cases of smaller installations, without having to use the above direct current formulae.

CURRENT REQUIRED BY MOTOR (Direct Current)

To find current required by a motor when the horsepower, efficiency and voltage are known, use the following formula:

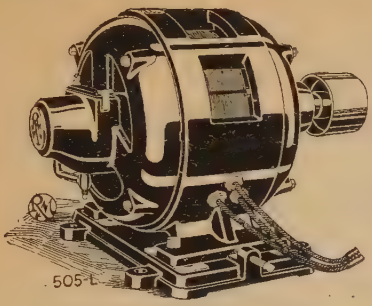
I = current to be found.
H.P. = horse-power of motor.
E = voltage of motor circuit.
K = efficiency of motor in per cent.

Then

$$I = \frac{\text{H.P.} \times 746 \times 100}{E \times K}$$

The table of "amperes per motor" given on the fol-

Robbins & Myers Motors and Fans



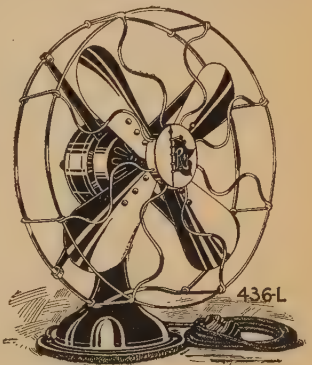
Type "K" Polyphase Motor.

The R & M line of motors includes sizes from 1/40 to 50 horsepower, inclusive, for direct or alternating current circuits. In addition to the standard frames, special frames can be furnished, adapted to the particular requirements of any motor driven machine.

Robbins & Myers Direct-Current Generators are made in capacities ranging from ¼ to 10 kilowatts, inclusive. They can be furnished with fly-wheel pulleys for service with gas engines.

The Robbins & Myers line of Fans includes types and sizes for all services for operation on all direct and alternating current circuits.

Bulletins on R & M Motors, Generators or Fans will be furnished on request.



12-Inch Fan, Drawn Steel Frame.

THE ROBBINS & MYERS CO.

SPRINGFIELD, OHIO

New York Boston | Philadelphia Buffalo | Cleveland Cincinnati | Chicago San Francisco | St. Louis

lowing pages will, in many cases, prevent the necessity of working out the above formula.

For alternating current motors use the table on page 10. For special cases not covered by this table use the following formula:

$$I = \frac{W}{E \times P.F.} \text{ for single phase circuit.}$$

$$I = 0.50 \times \frac{W}{E \times P.F.} \text{ for two-phase circuit.}$$

$$I = 0.58 \times \frac{W}{E \times P.F.} \text{ for three-phase circuit.}$$

I = line current in amperes per wire.
E = line voltage at delivery end.
W = watts energy to be delivered.
P.F. = power factor. (See page 395.)

Direct Current Motors

APPROXIMATE FULL LOAD CURRENT.

H. P.	Assumed Efficiency Per Cent	Amperes 110 V.	220 V.	500 V.
⅛	50	2.3	1.15	.50
¼	58	2.9	1.45	.51
½	66	5.2	2.6	1.14
¾	71	7.2	3.6	1.6
1	75	9.1	4.5	2.0
1½	78	13.1	6.5	2.9
2	79	17.2	8.6	3.8
3	82	24.8	12.4	5.4
4	83	32.9	16.4	7.0
5	85	40.1	20.1	8.8
7½	87	58.9	29.4	12.9
10	89	76.7	38.4	16.8
15	90	114.	57.0	25.1
20	90	151.	75.	33.
25	90	189.	94.	42.
30	90	227.	113.	50.
40	91	300.	150.	66.
50	91	375.	187.	82.
60	91	450.	225.	99.
75	91	562.	281.	124.
100	91	750.	375.	165.
150	92	1106.	553.	243.
125	91	940.	470.	207.
175	92	1290.	645.	284.
200	92	1475.	737.	324.
250	92	1840.	920.	405.
300	93	2185.	1093.	481.
400	93	2920.	1460.	728.
500	94	3600.	1800.	792.

Alternating Current Motors

APPROXIMATE FULL LOAD CURRENT.

H.P.	Single-Phase				Two-Phase				Three-Phase			
	110 V.	220 V.	440 V.	550 V.	110 V.	220 V.	440 V.	550 V.	110 V.	220 V.	440 V.	550 V.
⅙	4.0	2.0	1.0	.8	....	....	....	....	....	....	....	....
¼	4.5	2.2	1.1	.9	....	....	....	....	....	....	....	....
½	8.0	4.0	2.0	1.6	3.3	1.7	.9	.7	3.7	1.8	1.0	.75
¾	9.0	4.5	2.2	1.8	4.6	2.3	1.2	.9	5.3	2.7	1.3	1.1
1	13.	6.5	3.3	2.6	6.0	3.0	1.5	1.2	7.0	3.5	1.7	1.4
1½	18.	9.0	4.5	3.6	8.5	4.2	2.1	1.7	9.8	4.9	2.4	2.0
2	25.	12.5	6.2	5.0	10.5	5.2	2.6	2.1	12.	6.0	3.0	2.4
3	36.	18.	9.	4.5	15.	7.5	3.8	3.0	17.	8.5	4.2	3.4
4	48.	24.	12.	9.6	19.	9.5	4.8	3.8	22.	11.	5.5	4.4
5	60.	30.	15.	12.	27.	13.0	6.5	5.2	31.	15.	7.6	6.2
7½	90.	45.	22.	18.	40.	20.	10.	8.0	46.	23.	11.	9.2
10	115.	58.	29.	23.	50.	25.	12.	10.	58.	29.	14.	12.
15	150.	75.	37.	30.	70.	35.	18.	14.	81.	41.	20.	16.
20	200.	100.	50.	40.	96.	48.	24.	19.	110.	55.	27.	22.
25	250.	125.	62.	50.	108.	54.	27.	22.	125.	62.	31.	25.
30	300.	150.	75.	60.	140.	70.	35.	28.	162.	81.	40.	32.
40	400.	200.	100.	80.	190.	95.	47.	38.	220.	110.	55.	44.
50	....	....	....	....	....	110.	55.	44.	....	127.	63.	51.
60	....	....	....	....	....	132.	66.	53.	....	152.	76.	62.
75	....	....	....	....	....	165.	83.	65.	....	191.	96.	77.
100	....	....	....	....	....	215.	108.	86.	....	248.	124.	99.
125	....	....	....	....	....	270.	135.	108.	....	312.	156.	125.
150	....	....	....	....	....	320.	160.	128.	....	366.	183.	146.
175	....	....	....	....	....	370.	185.	149.	....	427.	213.	171.
200	....	....	....	....	....	410.	205.	164.	....	475.	237.	190.
250	....	....	....	....	....	510.	255.	204.	....	590.	295.	236.
300	....	....	....	....	....	600.	300.	240.	....	700.	350.	280.
400	....	....	....	....	....	800.	400.	320.	....	925.	462.	370.
500	....	....	....	....	....	1000.	500.	400.	....	1150.	575.	460.

SIZES OF FUSES, IN AMPERES, FOR MOTORS EQUIPPED WITH OVERLOAD STARTING RHEOSTATS.

Horsepower.	115 Volts.	220 Volts.	500 Volts.
0.5	8	4	2
1	15	8	4
2	30	15	7
3	40	20	10
4	50	25	12
5	60	30	15
7.5	90	45	20
10	115	60	25
15	175	90	40
20	225	115	50
25	300	150	60
30	350	175	75
35	400	200	90
40	450	225	100
50	600	300	125

TYPES OF DIRECT CURRENT MOTORS

Their Operation and Care.

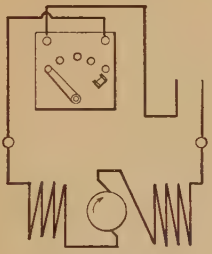
Shunt Motors—This is by far the most common type of winding, and is generally applied to motors designed for operating at constant speed under constant or varying loads. Nearly all commercial applications, particularly those of large capacity, require this type of motor. When necessary, considerable speed variation can usually be secured by means of a rheostate in the field circuit, increased resistance resulting in an increased speed.

Series Motors—Series motors are variable speed machines particularly adapted to a few special uses, such as railway and crane service, but are not extensively employed in the field of work to which this book is devoted. The characteristic feature of a series motor is its great torque at starting and low running speeds.

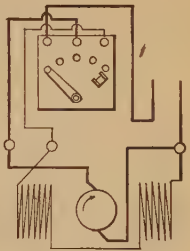
Compound-Wound Motors—For some special classes of service, in which it is necessary to start under heavy load and later operate at approximately constant speed, a series winding is added to assist the shunt field at the low speed points.

As in the case of the compound generator, a compound motor combines the characteristics of both shunt and series motors. In most cases, however, the series winding has comparatively little effect except during the starting period.

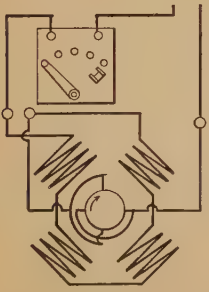
CONNECTIONS FOR DIRECT CURRENT MOTORS



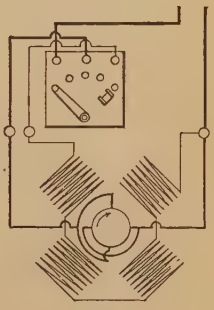
SERIES MOTOR
2-POLE



SHUNT MOTOR
2-POLE



SERIES MOTOR
4-POLE



SHUNT MOTOR
4-POLE

General Rules—Leave all switches open when machine is not running.

At all times keep the motor clean and free from oil and dust, especially from copper or carbon dust. With high-voltage machines a small accumulation of dust on the windings may be the cause of serious burn-out.

Keep small pieces of iron and bolts and tools away from the frame. Any such fragment attracted to the pole of a field magnet may jam between the armature and pole and cause serious damage.

Occasionally give the machine a thorough inspection. The higher the voltage of the motor, the oftener this should be done.

Starting Motors—See that the bearings are well supplied with oil and that the oil rings are free to turn. Inspect all connections for loose screws or wires.

Start slowly. See that the oil rings are revolving properly.

Starting Constant-Speed Motors, Shunt or Compound. See that bearings are well supplied with a good lubricating oil and that oil rings are free to turn. Inspect all connections for loose screws or wires.

Make sure that the lever arm of the starting box or controller is in the "off" position.

Close the main switch.

Close the field switch.

Move lever arm of starting box or controller to the running position, pausing long enough on each notch to allow the motor to come up to the speed of that notch.

If using a controller, throw the short-circuiting switch and move controller handle back to the starting position. If using a starting box, the lever arm should remain in the running position.

To Shut Down Constant-Speed Motors—Open the main switch or circuit-breaker.

After the motor has come to rest, see that the lever arm of the starting box is returned to its original position.

Open the field switches.

Clean the machine thoroughly and put in order for next run.

Starting Adjustable-Speed Motors—Examine shunt-field rheostat and see that all resistance is cut out.

Follow all directions given under "Constant Speed Motors."

After motor is running on full-line voltage, gradually

cut in resistance in the shunt-field rheostat until the motor is up to the desired speed.

To Shut Down Adjustable-Speed Motors—Gradually cut out the resistance in the shunt-field rheostat until the machine is running on a full field.

Follow directions given under "To Shut Down Constant Speed Motors."

Starting Series Motors—Follow same instructions as those given for "Starting Constant Speed Motors," except there is no field switch to close.

To Shut Down Series Motors—Open main switch.

Examine machine carefully; wipe off all dirt or oil, and put in good shape for next run.

Brushes.—See page 319.

Commutator.—See page 321.

Bearings.—See page 325.

Hot Box.—See page 323.

Belts.—See page 323.

Sparking.—See page 324.

Heating of Field Coils or Armature.—See page 325.

STORAGE BATTERIES

When current for light and power is taken from storage batteries, the same general regulations for wiring should be observed as apply to similar apparatus fed from generators developing the same difference of potential.

All secondary batteries should be mounted on non-absorptive, non-combustible insulators, such as glass or thoroughly vitrified and glazed porcelain.

The use of any metal liable to corrosion should be avoided in cell connections of storage batteries.

Storage batteries should be made inaccessible to other than properly qualified persons by being placed in a separate room or inclosure.

Rooms or inclosures containing storage batteries should be so ventilated as to remove acid spray and prevent dangerous accumulation of inflammable gas.

The battery room ventilating system should be so arranged as not to carry any gases therefrom into other rooms or spaces of the building where electrical apparatus or equipment is located.

Suitable drainage or other means should be provided beneath cells to prevent the accumulation of electrolyte in case of leakage or spraying.

Acid-resistive floors, such as vitrified brick set in pitch, are recommended where large batteries are installed.

The arrangement of cells and connections should be such that no two current-carrying parts between which a voltage exceeding 150 exists, shall be closer than 3 feet, if the parts are so exposed that persons are liable to make accidental contact with both at the same time.

No conductor above 150 volts to ground should be placed in any passageway, unless guarded or isolated by elevation.

Storage-battery rooms should be lighted, if practicable, from outside lamps and open-flame heating devices should not be installed.

If lamps are inside, only incandescent electric lamps in keyless porcelain or composition sockets, controlled from points not exposed to battery vapor, should be used.

Conductors in battery rooms, if of such material or so located as to be liable to corrosion, should have suitable protective coverings or coatings, unless the ventilation is such as to render this unnecessary.

All wiring in rooms containing storage batteries, of the lead and sulphuric acid types, should be done with approved rubber covered wire, although approved weatherproof wire is allowed.

All such wiring should be rigidly supported on approved insulators which separate the wires at least one inch from the surface wired over and kept apart at least two and one-half inches for voltages up to 300, and four inches for higher voltages.

CARE AND OPERATION OF LEAD BATTERIES

It is an unfortunate fact that among battery users and even the electrical profession generally there is very little really known about the performance and care of storage batteries.

It is the purpose of this section to explain in simple language the action of the lead storage battery and to recite the important points of the proper manner for caring for storage batteries in operation, and to give the reasons for such rules as are laid down by the manufacturers for the proper care of the battery; and in this connection to point out the penalties that must be paid if these instructions are not followed.

A storage battery consists of one or more cells; each cell consists of positive and negative plates immersed in an electrolyte. The electrolyte of all lead storage batteries consists of a mixture of sulphuric acid and water in such proportion as to best meet the require-

ments of the service in which they are to be used.

The voltage of each cell is approximately 2 volts on open circuit, but is higher than this when the battery is being charged and lower while being discharged. The nominal voltage of a battery is, therefore, the number of cells multiplied by two.

When a cell is being discharged the current is produced by the acid in the electrolyte combining with the active material of the plates. The active material of the positive plate is lead peroxide and that of the negative is metallic lead in a spongy form. When the acid combines with the active material, lead sulphate is formed in both the positive and negative plates. The sulphuric acid, which has been absorbed by the plates, has, of course, been withdrawn from the electrolyte, with the result that the specific gravity of the electrolyte is reduced, and for a full discharge this drop in gravity will be from 12 to 125 points, depending on the type of cell and the amount of the discharge.

To recharge the battery, **direct current** must be passed through the cells in a direction opposite to that of the current during discharge. This reversed current will reverse the action which took place in these cells during discharge. It will, therefore, withdraw the acid from the active material in the plates and restore it to the electrolyte. Thus, during the charge the electrolyte gradually becomes stronger as the acid is withdrawn from the plate until no more sulphate remains in the active material. All the acid having been returned to the electrolyte, it will be of the same strength as before the discharge, and the same acid will be ready to use over again during the next discharge, and the active material of the plate again in condition to combine with this acid.

Discharge—Operating instructions for storage batteries as issued by the manufacturers usually say very little about discharging. As a matter of fact, a battery may, without injury to the plates, be discharged at any rate of current that it will deliver. There has been a wide-spread opinion that high rates of discharges are detrimental to the life of a battery. There is no justification for this opinion with modern storage batteries. The maximum permissible rate of discharge is usually limited by the size of wiring used or by the capacity of the motor or other apparatus to which it is connected, and not by the battery itself. Caution should be given, however, against over-discharging the battery. We have already pointed out that the drop in specific grav-

ity of electrolyte should not exceed a certain definite number of points, the number depending on the type of cell. Some of you have perhaps noticed the action of sulphuric acid on copper wiring terminals of a battery, and that a comparatively large amount of copper sulphate is formed when only a small quantity of the metal is eaten away by the acid. In the same manner, when the acid combines with the lead in the active material, the resulting lead sulphate occupies more space than the active material from which it is formed. The active material of all battery plates is porous, and this expansion of the material is accommodated by reducing the size of pores in the active material. All battery plates are designed to accommodate a certain amount of this expansion of the active material during sulphation. This is limited to the amount represented by a definite drop in gravity, as already mentioned. Further discharge, even if it can be obtained at a satisfactory voltage, results in an excessive expansion, which so closes the pores in the active material that it becomes increasingly difficult to properly recharge the battery after an excessive discharge, and unless a proper recharge is given, the battery is liable to deteriorate. For this reason the discharge of any battery should not be carried beyond the point given by the manufacturers, as indicated by a hydrometer or by an ampere hour meter.

The function of an ampere hour meter is to show the state of charge of the battery at all times and, therefore, indicate directly when the battery is approaching its limit of discharge as well as when it is approaching a state of full charge. To do this, it must be connected in the battery circuit at all times.

Charging—Operating instructions as issued by the manufacturers devote much more space to charging than to discharging. A battery must, of course, be charged with direct current, and the current must be connected to the battery so that it will go through it in the proper direction. The positive pole of the charging source must be connected to the positive terminal of the battery.

While a battery is being charged, the amount of sulphate in the plates decreases, the ability of the plate to give up the acid becomes reduced; in other words, during the early part of a charge the plates can give up the acid at a rapid rate, as there is a large amount of sulphate available. Therefore, a battery that is considerably discharged can be charged at a high rate, but

as the charge approaches completion, currents at high rate cannot be utilized, and if high rates are maintained, only a portion of the current is used to withdraw acid from the plates, and the balance of the current acts to decompose the water in the electrolyte into oxygen and hydrogen, which are given off in the form of gas. Gassing of the battery, therefore, shows at any time whether or not the charging rate is too high. It, therefore, follows that when the cells are gassing on charge the rate of charge should be reduced. This reduction saves the loss of current, which is shown by the gassing; also, this gassing in excess has a wearing effect on the battery, which will be discussed further a little later.

The hydrogen and oxygen given off from the battery, when unmixed with a large amount of air, form a combination that will explode violently if ignited by an open flame or an electric spark. The room or compartment should, therefore, be ventilated while the battery is being charged, in order that these gases may become mixed with air. Do not bring exposed flame, match, candle, cigar and so forth near the battery when charging or shortly after. If the battery is to be charged in a closed room, especial attention should be paid to the ventilation of the charging room.

We have already pointed out that gassing represents a waste of charging current. It does more than this. The action of the bubbles of gas in escaping from the pores of the plates and in "boiling" to the top of the electrolyte have a tendency to wash the active material from the positive plate.

It is a well-known fact that batteries wear out. This wear shows itself to the eye principally in the positive plate, the active material of which softens with use, and falls to the bottom of the jar in the form of sediment. The action of the gas in escaping from the pores of the plate and the eddy currents stirred up in the electrolyte when the bubbles of gas boil to the surface hasten this shedding of material and, by just that much, shorten the life of the battery.

Excessive gassing should, therefore, be avoided if the best life of the battery is to be obtained. A small amount of gassing at low rates and for a short time, at the completion of a charge, is not objectionable, but violent gassing having the appearance of boiling should be avoided.

High Temperature—The cell temperature should not exceed 110 degrees Fahrenheit. The effect of high temperature is primarily to shorten the life of the wood separators which are always installed between the positive and negative plates.

There is always a tendency for wood in contact with sulphuric acid to become carbonized. This tendency is much accelerated at temperatures in excess of 110 degrees Fahrenheit; and if a battery is regularly operated at temperatures in excess of this amount, it will probably be necessary to renew separators in the entire battery prior to the battery itself having ended its useful life.

There are also present in any commercial storage battery some impurities in the materials used, which cause very slight action in the cell, even when it is not in active operation. At high temperatures, these internal losses are increased, as is evidenced by the fact that a battery placed in storage will not lose its charge seriously over a period of, say, six months if kept in a cool place. If kept at a temperature around even 100 degrees Fahrenheit, it will lose much more of its charge in, say, three months.

In operation, however, the principal effect of high temperature of a battery is its deteriorating effect on the separators.

Charging Rates—With the above limitations in mind, it is advisable to charge a battery at relatively low rates if local conditions permit. Of course, the lower the rate of charge the longer the time required to complete the charge. If twelve or fourteen hours are available, the charging can be done at a low rate. If this length of time is not available, the charging rate should be higher at the start of charge and then reduced to the finishing rate before the battery begins to gas.

Where an ampere hour meter is used, the following general rule can be given: the charging rate in amperes must be less than the ampere hours still out of the battery until the finishing rate is reached. In other words, the ampere hour meter will always indicate a rate which should not be exceeded at that time. Of course, any rate less than that indicated by the ampere hour meter will be satisfactory.

More complete charging instructions are given in the instruction books issued by the manufacturers, but these instructions all conform to the general principles which have just been laid down. The important points

are: Avoid gassing and keep the cell temperature below 110 degrees Fahrenheit.

Boosting—There has been considerable said about boosting storage batteries. Boosting consists of giving a battery a partial charge, usually at a high ampere rate and for a relatively short time. Boosting in no way differs from charging and, therefore, the same rules should be followed.

Equalizing Charge—It is very important to give the battery a weekly equalizing charge, which consists of a prolonged charge at a low rate, until the specific gravity of the electrolyte will show no further rise over a period of one hour. As has already been pointed out, the object of charging is to withdraw all acid from the plates. In practice, the regular daily charges are not always given long enough to completely withdraw all the acid from the plates. In fact this is not necessary, provided the acid is completely withdrawn once a week by giving an equalizing charge. If this is not done and some sulphate is allowed to remain in the plates for a considerable time, if will gradually increase and the pores of the plate will become clogged and the battery lose capacity and deteriorate in such a way that it becomes increasingly difficult to restore the battery to its normal condition. To carry the daily charge to the full extent would involve an unnecessary amount of charging and gassing, which is not desirable. An equalizing charge properly given once a week accomplishes the desired result with a minimum of attention and a minimum of battery wear.

Watering—It is important that the plates of the battery be always covered with electrolyte. In order to accomplish this, it is necessary once a week, or possibly oftener, to add sufficient pure water to each cell to bring the electrolyte well above the tops of the plates. Use pure water for this purpose.

To determine whether natural water is sufficiently pure to use, a one-pint sample should be submitted to the battery manufacturer, who will make a chemical analysis of it, free of charge, and report to the user. If natural water is not sufficiently pure, it will be necessary to use distilled water, which can usually be purchased, or a small still may be installed by the user.

While the amount of impurities put into a cell at any one time may seem very small, the impurities accumulate with each filling, and will in time be present in such quantities as to effect the life of the cell.

The assembly of the cells is such that practically no

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Railway Car Lighting.
The Electrification of Railway Terminals.
Submarine Gun Firing and other Army and Navy Service.
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water really evaporates, the bulk of the loss is due to disintegration of the water by the gassing at the end of the charge. No acid is lost in this manner, so none should be added to the cells unless some has been lost by spilling. Water should be added to the cells before charging in order that it may become thoroughly mixed with the electrolyte by such gassing as occurs. This is particularly necessary in freezing weather, as otherwise the water will remain unmixed and may freeze.

Keep the Battery Clean. Any piece of electrical apparatus should be kept clean and dry, in order that there may be no loss due to poor insulation. If the battery is not kept clean, the acid will slowly attack the woodwork about the cells and may cause a failure of the insulation of the battery in such a way as to possibly cause short circuits or a spark which may ignite gases around the battery and cause an explosion.

The battery should be inspected regularly and given such attention as may be required. Any piece of apparatus in daily use requires periodic inspections, followed by such cleaning and repairs as may be found necessary if the best results are to be obtained. Such inspections are less burdensome than the troubles which result with any piece of apparatus that is not properly cared for.

Conclusion—The action of the storage battery is relatively simple. The attention that it requires to keep it in regular daily service is simple and easily given. The mystery that exists in some people's minds regarding the battery is due to the fact that it does not complain under abuse. The operators do not appreciate, from their own observation, the results of abuse and so, in many cases, do not give the battery the attention that it deserves.

CARE AND OPERATION OF EDISON STORAGE BATTERIES

The same installation rules governing the installation of lead batteries apply to the installation of Alkaline or Edison Batteries.

The Edison battery has different voltage characteristics than the lead battery. No lead is used in its construction and the electrolyte is a solution of caustic potash instead of sulphuric acid. The peculiarities of construction and the character of the materials used

enable the manufacturers to claim a long term of service for the cells.

The grids for both positive and negative plates are stampings from sheet steel. These, as well as all other steel parts used in the assembled cell, are nickel plated to prevent corrosion. The active material is contained in tubes or pockets, fastened rigidly to the supporting frame or grid and giving electrical conductivity.

The cell is filled with electrolyte until a level of about ½ in. above the tops of the plates is reached. The cell is then ready for the forming charges and service conditions.

Inspection at regular intervals should be made of the height of the solution level—½ in. above the tops of the plates for the A-3, A-4, A-5, A-6, A-8, A-10 and A-12 types—taking care to close the filler caps after the inspection.

In making connections connect the positive pole of the end cell of one tray to the negative pole of the next, and so on.

Charging—Before charging, the battery compartments should always be opened in order to allow ventilation. Inspection should be made of the height of the electrolyte and if not found to be correct, then it should be brought to the proper level by the addition of distilled water only.

The charging voltage required for various numbers of cells usually encountered is given in the following table:

VOLTS REQUIRED TO CHARGE EDISON BATTERIES.

No. of Cells	Volts Across Cells	No. of Cells	Volts Across Cells
10	18.5	60	111.0
20	37.0	70	130.0
30	55.5	80	148.0
40	74.0	90	167.0
50	92.5	100	185.0

These voltages are the lowest sufficient to charge the numbers of cells given in series, at the normal rate toward the end of charge. While a few per cent. reduction in voltage will not materially affect the charge, allowance should be provided if it is required to charge at higher rates or charge several combinations of cells.

The initial charge should last for 12 hours at the normal rate for service. The "Normal Rate" is the catalogue rate of current for charge or discharge prescribed by the manufacturer.

ELECTRICAL DATA.

Type of cell	A-3	A-4	A-5	A-6	A-8	A-10	A-12
Capacity, ampere hours	112.5	150	187.5	225	300	375	450
Normal charge rate, Amperes	22.5	30	37.5	45	60	75	90
Normal discharge rate, Amperes	22.5	30	37.5	45	60	75	90

The normal charge for a battery practically discharged is seven hours at the normal rate. Should conditions prevent maintaining the normal rate, then the rate at the beginning may be set at a value approximately 50% above the normal. This figure will vary somewhat depending upon the amount of resistance in the charging circuit. As the battery voltages rises, during the progress of the charge, this rate decreases and the average charging current will be approximately the normal rate prescribed.

When the battery is not fully discharged sufficient charging need only be furnished to compensate for the capacity removed. If the cells are half discharged then half of seven hours or three and one-half hours' charge at the normal rate or its equivalent is necessary. In other words, it is necessary to make the ampere-hour input about 20-25 per cent. greater than the ampere-hour output or, if an ampere hour meter is used, set to operate 20 per cent. slow on charge.

The battery may be charged at any time, be the state of charge what it may, or may be discharged without other consideration than that of the capacity needed.

Overcharge. The first charge of the battery should be an overcharge; that is, charging for twelve hours at the normal rate. This operation should be repeated after thirty and sixty days of service and after each renewal of solution.

Boosting. Hastening a charge, familiarly known as "Boosting," may in general be accomplished by using a high charging rate, the value of the current being governed by the temperature of the cells, a temperature of 115 degrees being a practical limit. Experiment under many conditions has shown that the following rates are permissible. Temperature not to exceed 115° F.

5 minutes at five times normal rate
or 15 " " four " " "
or 30 " " three " " "
or 60 " " two " " "

To secure the best results it is not advisable to charge at less than the normal rate as a lower discharge voltage will result. In cold weather the charging rate should be above rather than below the normal

rate in order to heat the cells before use. Where a battery is to be used in a locality of exceptionally low temperature and may be allowed to stand for hours at a time, then the battery compartment should be suitably protected from air circulation so that the heat may be retained and the output of the battery thus increased. If this means be made use of, however, the compartment should be returned to its original condition when moderate temperature conditions return, as the temperature of the cells would rise above that recommended for the most efficient results and a long life.

Discharge. Very little need be said in regard to the discharge except that for continuous operation the rate of discharge should be at normal for best operation. This, of course, does not affect suddent or short overload conditions at which there is no limit to the discharge current.

Solution. The cells as received from the manufacturer are filled with electrolyte of proper strength and (providing no accident has occurred) to the correct level as previously explained. As the battery is charged this level is reduced owing to evaporation of solution by gassing produced by the passage of current. As this evaporation is nearly entirely water, distilled water only should be used for replenishing; never potash. Water should not be spilled on cells or trays, and the filler caps should be closed except when filling or testing for height of solution.

The distilled water should be kept in carboys which have held no acid and which are distinctly labeled, so that by no possibility may acid be introduced.

With use, the specific gravity of the solution will decrease in ordinary service, so that after a period of approximately eight to twelve months of continuous daily service or its equivalent, the solution should be tested with a hydrometer, and if the readings of a majority of the cells are below 1.160, after full charge, the solution should be renewed. The weight necessary per cell is given in the table below.

WEIGHT OF ELECTROLYTE REQUIRED IN RENEWAL.

Type of cell.....	A-3	A-4	A-5	A-6	A-8	A-10	A-12
Weight of solution to refill one cell, in pounds....	2.4	3	3.6	4.3	5.8	8.2	9.7

Having the necessary amount of solution at hand, the battery should be thoroughly discharged, removed

from the battery compartment and the solution removed by inverting the trays. Sloppage over the cans and trays should be avoided.

Remember

1. Never put acid into an Edison battery or use utensils that have been used for acid; you may ruin the battery.
2. Never bring a naked flame near the battery.
3. Never lay tools or pieces of metal on the battery.
4. Keep the filler caps closed at all times except when necessary for filling.
5. Keep the cells filled to the proper level by adding distilled water only.
6. Keep the cells externally as clean and dry as practicable.

THE ELECTRIC VEHICLE HAND BOOK

Any reader of this book who owns or operates storage batteries in connection with electric vehicles, electric trucks or electric industrial trucks and wishes to go even further into the subject should secure a copy of the latest edition of "The Electric Vehicle Hand Book." It is the only book on the subject published, and gives all the latest information on the care and handling of electric vehicles of every sort—their motors, controllers, storage batteries, tires, running gear and how to get the most efficient results from vehicles of this class. The book is handsomely bound in flexible leather cover—388 pages with over 200 illustrations, tables, etc. It will be mailed to any one postpaid on receipt of the price, two dollars, by H. C. Cushing, Jr., Publisher, 8 West 40th St., New York.

ILLUMINATION.

Illumination is the result of light falling upon objects ,and is the physical cause of the mental act of seeing. The object of artificial illumination is to render objects visible, and its success depends upon the quickness, ease, and accuracy with which the desired objects can be seen.

Illumination is judged from the two different standpoints of cause and effect. Considered as a cause, illumination is measurable by physical standards, and its efficiency capable of statement in mathematical terms. Considered as an effect, its differences can be stated only as varying degrees of quality. In order to understand these two meanings of the term illumination we must consider the nature of

Light, which is a form of energy capable of producing radiations which cause the sensation of vision. A body producing such radiations is a **Luminous Body,** and a surface upon which such radiations fall is an **Illuminated Surface.**

Light, in common with other forms of energy which act through space, spreads out uniformly in all directions from the luminous source, which in mathematical calculations must be considered a **point,** and the actual luminous body as made up of an infinite number of these points. This fact is stated as a physical law by saying that **light travels in straight lines, and equally in all directions from the source.** In this statement it is assumed that the space in which it travels is of uniform character. If the character of the space changes, as from air to glass, the path of the light radiations changes. This change in direction is called **Refraction.** Lenses are transparent bodies shaped to take advantage of refraction, generally to produce apparent change in the size of objects, but in the case of the camera and the eye, simply to produce images of objects. The laws of refraction belong to the Science of Optics, and have no practical bearing on the subject of general illumination.

When light falls upon a physical surface various results follow, according to the nature of the substance, the character of the surface, and the direction in which the rays meet the surface. The substance may be **Transparent,** allowing objects to be seen through it; **Translucent,** allowing light to pass through but not so as to distinguish objects; or **Opaque,** not permitting the rays to pass through.

Light falling upon the surfaces of transparent or translucent substances undergoes three changes: a portion is **reflected**; a portion is **transmitted**, and the remaining portion **absorbed.** Light falling upon the surfaces of opaque bodies suffers two changes: a portion is reflected and the remainder absorbed.

Reflections follows a single law: **The angles of incidence and reflections are equal, and in the same plane.** The character of the surface, however, produces very great differences in the **visual effects** produced. If the surface is **plane,** like that of still water or sheet glass, objects may be seen by the reflected light; this is called **Regular** or **Specular Reflection.** If the surface is rough, like ground glass, or white paper, the surface merely appears illuminated: this is called **Irregular,** or **Diffuse Reflection.** Actual surfaces give both kinds of reflection to some extent. Polished or "shiny" surfaces give more regular than irregular reflection; "matt" surfaces give more irregular reflection.

With one exception reflection always means a loss of light. This exception is the case known as **Total Reflection,** and may be considered as a special case of refraction. It is utilized in prismatic reflectors.

The proportion of light reflected from a surface is called the **Coëfficient of Reflection** of that surface.

The coëfficients of reflection of various surfaces are as given below:

White paper	60-75
White paint	40-60
White finish plaster	60-90
White tile	50-70
Buff walls	40-50
Black paper	6-10
Black velvet	2- 3
Mirror glass	83-95
Wall paper	10-50

The coëfficients of absorption of various transparent and translucent substances are as follows:

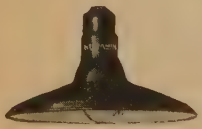
Clear glass	5-12
Frosted glass	10-30
Ribbed glass	15-30
White glass	10-75
Prism glass	15-20

Light varies in **intensity** and **quality.** Intensity is a physical property due to the energy of the radiations. It is measured by comparison with a standard light-source. The standard of measurement is (theoretically) the candle. A light of one **candle-power** is a light that

REFLECTOR SOCKETS

Dome (R.L.M.)

Deep Bowl



Shallow Bowl

Flat Cone

Parabolite

Elliptical Angle Reflector

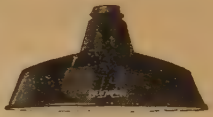
BENJAMIN PRODUCTS

OUR AIM THE RIGHT REFLECTOR in the RIGHT PLACE

Our New Industrial Lighting Bulletin 17 Will Show You How

Write for a copy

SHADEHOLDER REFLECTORS



Dome (R.L.M.)

Deep Bowl

Angle

Shallow Bowl

Focusing

BENJAMIN ELECTRIC MFG. CO.

New York Chicago San Francisco

London Toronto

produces the same brightness on a white surface as that produced by a standard candle placed at the same distance from the surface; a light of two candle-power, the same brightness as two candles at the same distance—and so on. It has been customary to say that **"Light varies inversely as the square of the distance"** (from the source). In practical photometry it is more useful to say that **illumination** varies inversely with the square of the distance from the light-source: e. g., a surface at two feet from a candle is one-quarter as brightly illuminated as a surface one foot from the candle.

Intensity of light must not be confused with **quantity of light. Intensity** is exactly analogous to **temperature** in heat; **quantity** is the equivalent of thermal units ("B. T. U."). The **unit quantity** of light is the Lumen, and **is the quantity of light** (amount of energy) **received by a surface of one square foot at a distance of one foot from a light-source of one candle-power.** The intensity of illumination on such a surface is one foot-candle. A lumen is therefore defined as the quantity of light necessary to illuminate an area of one square foot with an intensity of one foot-candle.

The varying **quality of light** is recognized as differences in **Color,** and arises from physical differences in the radiations.

Light Sources are physical bodies generating light; in other words, luminous surfaces. Together with the necessary mechanical contrivances for their maintenance they form **lamps.** Of the numerous forms of electric lamps that have been devised, only two types remain from which to choose for modern illumination: the incandescent (filament) and the mercury vapor lamp. The former contains three varieties—the carbon filament, the tungsten vacuum and the tungsten gas-filled lamps. The carbon lamp is used only where it is subjected to much jarring, as in hand lamps for shipbuilding and other large work. The tungsten vacuum is used in the smaller sizes, 60-watt and under; the gas-filled in the larger sizes, 60-watt and upward. The gas-filled—commonly called "nitrogen lamps"—are about twice as efficient as the vacuum lamps.

Practical illumination deals with two fundamental types of apparatus: Lamps and their accessories, for **producing** the illumination; and the **organs of vision,** upon which the illumination acts. The **efficiency** of a system of illumination is commonly understood to mean **the ratio of the total quantity of light generated**

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to the quantity of light falling upon a theoretical plane 30 inches from the floor, called the **Working Plane.** This mathematical efficiency does not necessarily correspond with the efficiency with which the visual organs perform their functions under a given illumination. There are many factors besides mere brightness at the working plane that affect the process of seeing. Probably the principal factor is

Glare. Glare is a fogging of the retinal image produced by a spot or point that has a much greater intensity than the surrounding field. The eye is an optical apparatus identical in principle with the camera, the retina receiving the images as the sensitive plate receives them in the camera. **Glare in illumination is a condition that would produce halation in a photograph.** Glare depends more upon the degree of contrast, i. e., the relative intensities of the bright spot and the field than upon the size of the bright spot. A dazzling point is more troublesome than a larger area of less intensity. Reflections from bare light-sources by small polished surfaces, such as spots of oil, may seriously impair the visual results. Glare always interferes with normal vision, and may produce any degree of inconvenience from just perceptible discomfort to the complete loss of sight. All forms of electric lamps except the Cooper Hewitt (mercury vapor) produce intense glare when used for direct lighting.

The eye is capable of seeing by very great differences in illumination intensity; a range of from one to 100,000 would be a fair approximation. The most efficient vision, however, is limited to a comparatively narrow range; but even in this case a difference of 100 per cent in intensity will make no serious disturbance. For this reason tables of intensities required for various purposes will be found to give considerable latitude (see Table, page 364).

The **illumination** of an object is determined by the **light falling upon it. Vision** is the result of **light entering the eye.** The amount of light entering the eye from a given object depends upon (1) the amount of light falling upon the object, and (2) the proportion of this light which the object reflects. The latter, (2), is called the **apparent brightness** of the object. Thus, white paper will have 30 times the apparent brightness of black velvet under the same illumination. It is obvious that the reflective power of the objects to be seen must be carefully considered in determining the

quantity of light to be provided for any given purpose.

Acuity (sharpness) **of vision** is distinctly affected by the color composition of the light entering the eye. The lens of the eye is subject to **chromatic aberration** (the production of color-fringes in the image). If the light is monochromatic (consisting of only one color), these fringes are not formed, and the image is perfectly sharp, producing the highest degree of acuity. **The nearer the light comes to being monochromatic, the sharper the vision.** Mercury vapor light contains no red, and is approximately monochromatic. It consequently produces a marked increase in visual acuity over other forms of electric light, which contain all the colors. For this reason it is especially adapted to industrial lighting.

Color is the esthetic, or decorative, feature of illumination. That it is not an essential element in human vision is shown by the fact that persons who are totally color-blind suffer only superficial inconvenience. Color, therefore, belongs rather to the field of the artist than of the engineer.

Illuminating Systems are arrangments of light-sources and accessories designed to illuminate specific areas or spaces, to accomplish certain definite purposes. The general purposes of illumination fall under two grand divisions: (1) **Social Lighting,** and (2) **Industrial Lighting.** These are best defined by saying that industrial lighting is for the purpose of allowing manual labor to be carried on, and social lighting is to allow the performance of all other human activities. Industrial lighting is strictly utilitarian, while social lighting involves esthetic as well as practical considerations. **The true efficiency of an industrial lighting system** is measured by the output of those working under it compared to the output under standard daylight. 100 per cent. efficiency is easily obtainable, and in special cases has been exceeded. The elements of vision concerned in industrial lighting are: (1) **Ease,** (2), **Rapidity,** (3), **Acuity.** Ease is secured by elimination of glare, sharp shadows and a multiplicity of light sources. Rapidity requires the proper apparent brightness. Acuity depends upon color-composition, other conditions being the same.

In social lighting, "appearances count"—often more than technical results. High acuity is not essential, and in many cases positively is undesirable. Ease is generally desirable, but may be sacrificed to a certain

extent for the sake of spectacular effect—as in a ballroom. Rapidity is of secondary consideration. There is, however a class of cases which contain certain elements of industrial lighting, and in which the functions of vision should not be subordinated to appearances. This class includes all activities concerned with reading and writing.

Social lighting is accomplished, generally speaking, by three different methods: (1) Direct lighting, (2) Indirect lighting, (3) Semi-indirect lighting. In direct lighting the aim is to throw the rays from the light-sources, primary or secondary, directly upon the objects to be illuminated. A **Primary Light-source** is one without accessories; a **Secondary Light-source** is an accessory which receives light from the source and passes it on in a modified form, e. g., a ground class globe, or a reflector. Indirect lighting is accomplished by throwing the light onto the ceiling or side walls, or both, and using their surfaces as the secondary light-source, the primary light-source being entirely hidden. Semi-indirect lighting is a combination of direct and indirect; the term is especially applied to the use of white, translucent bowls, which transmit a minor portion of the light, the major portion illuminating the ceiling. Indirect lighting fulfills all three essentials of vision for social lighting to the maximum degree, and is therefore the most efficient in results. Semi-indirect is generally considered to have higher esthetic quality. For utilitarian social lighting—for purposes of reading and writing—the indirect method is to be preferred. In other cases taste will generally be the deciding factor.

The efficiency of various systems of direct lighting are approximately as follows:

One-piece Mirror Glass Reflector	65	per cent.
Clear Prismatic Reflectors	55	"
Heavy Density Opal Reflectors	45	"
Aluminized Metal Reflectors	45	"
Medium Density Opal Reflectors	40	"
Satin Finished Prismatic Reflectors	40	"
Porcelain Enameled Steel Reflectors	40	"
Opal Enclosing Globes	35	"
Bare Lamps	28	"

Illumination Required for Various Classes of Service

Service.	Foot Candles.
Armory	2 — 3
Auditorium	1 — 3
Automobile, Garage	2 — 3
Automobile, Showroom	4 — 6
Ball Room	2 — 3
Bank	3 — 4
Billboard	5 —15
Billiard Room, General	1 — 2
Billiard Room, Table	5 — 8
Bowling Alley, Pins	4 — 0
Bowling Alley, Alley	1 — 0
Barber Shops*	3 — 5
Cafe	2 — 4
Cars, Street	2 — 3
Court, Tennis	5 — 8
Court, Handball	5 — 8
Church	1 — 3
Corridor	0.5— 1.5
Court Room	2 — 4
Desk*	4 — 6
Draughting Room*	7 —10
Gymnasium	1 — 3
Hospital, Operating Table	12 —18
Hospital, Ward	1 — 2
Hotel, Dining Room	1 — 4
Hotel, Guest Room	1.5— 2
Hotel, Lobby	2 — 4
Hotel, Writing Room	2 — 4
Library, Reading Room*	3 — 4
Library, Stack Room	1.5— 2
Lunch Room	2 — 4
Market	2 — 4
Moving Picture*	0.5— 1.5
Museum	2 — 4
Office*	4 — 5
Power House	2 — 3
Residence	1 — 2
Restaurant	2 — 5
School*	3 — 4
Show Window	10 —40
Stock Room	0.5— 2
Store, Clothing	4 — 7
Store, Drug	4 — 6
Store, Dry Goods	3 — 6

*Some form of Semi-indirect or Totally Indirect lighting particularly desirable.

The following formulæ will be of assistance in calculating illumination:

C.P. = Candle Power.
M.H.C.P. = Mean Horizontal Candle Power.
M.S.C.P. = Means Spherical Candle Power.
R.F. = Reduction Factor (Expressed as decimal).
W. = Energy in Watts.
L. = Total Lumens.
L (e) = Lumens effective at working plane.
L per W = Lumens per Watt (Measure of Lamp Efficiency).
W per CP = Watts per Candle Power.
Ft.Cd. = Illumination (lumens per square foot).
W. = C.P. × (W. per C.P.)

$$\text{W. per C.P.} = \frac{\text{W}}{\text{C.P.}}$$

$$\text{Candle Power of a lamp—(M.H.C.P.)} = \frac{\text{W}}{\text{W. per C.P.}}$$

M.S.C.P. = M.H.C.P. × R.F.
Lumens of Lamp = W × (Lumens per W.).
Lumens of Lamp = M.S.C.P. × 12.57 = M.H.C.P. × R.F. × 12.57.

$$\text{Efficiency of Lamp} = \text{Lumens per Watt} = \frac{\text{L}}{\text{W}}$$

Total Lumens available = L. per W. × W × No. of Lamps.
L(e) = L × Efficiency of Lighting System.

$$\text{Ft.Cd.} = \frac{\text{L(e)}}{\text{Sq. Ft.}} = \frac{\text{L} \times \text{Eff. of System}}{\text{Sq. Ft. (Area to be lighted)}}$$

L(e) = Ft.Cd. × Sq. Ft.
Efficiency of Lighting System

$$= \frac{\text{L(e)}}{\text{L}} = \frac{\text{Ft.Cd.} \times \text{Sq. Ft.}}{\text{Total lumens of lamps}}$$

$$= \frac{\text{Ft.Cd.} \times \text{Sq. Ft.}}{\text{M.S.C.P.} \times 12.57 \times \text{No. Lamps}}$$

MAZDA LAMP DATA

1920

Mazda B Lamps for Standard Lighting Service—Straight Side Bulbs.

Volts	Watts	Bulb	Lumens	Watts per Sph. C.P.	Base
110 to 125	10	S-17	75	1.67	Medium Screw
	15	S-17	125	1.51	" "
	25	S-17	226	1.39	" "
	40	S-19	370	1.36	" "
	50	S-19	472	1.33	" "
	60	S-21	575	1.31	" "

Mill Type Mazda Lamps for Standard Lighting Service—Straight Side Bulbs.

110 to 125	25	S-19	210	1.50	Medium Screw
	50	S-19	436	1.44	" "

Mazda C Lamps for Standard Lighting Service—Pear Shape Bulbs.

110 to 125	50	PS-20	450	....	Medium Screw
	75	PS-22	865	1.09	" "
	100	PS-25	1260	1.00	" "
	150	PS-25	2040	.92	" "
	200	PS-30	3100	.81	" "
	300	PS-35	4840	.78	Mogul Screw
	500	PS-40	8750	.72	" "
	750	PS-52	13900	.68	" "
	1000	PS-52	19300	.65	" "

Mazda B Lamps for Standard Lighting Service—Straight Side Bulbs.

220 to 250	25	S-19	191	1.65	Medium Screw
	50	S-19	442	1.42	" "
	100	S-30	945	1.33	Med. Sc. Skirted

Mill Type Mazda Lamps for Standard Lighting Service—Straight Side Bulbs.

220 to 250	25	S-19	178	1.77	Medium Screw
	50	S-19	388	1.62	" "

Mazda C Lamps for Standard Lighting Service—Pear Shape Bulbs.

220 to 250	200	PS-30	2520	1.00	Medium Screw
	300	PS-35	4100	.92	Mogul "
	500	PS-40	7850	.80	" "
	1000	PS-52	17500	.72	" "

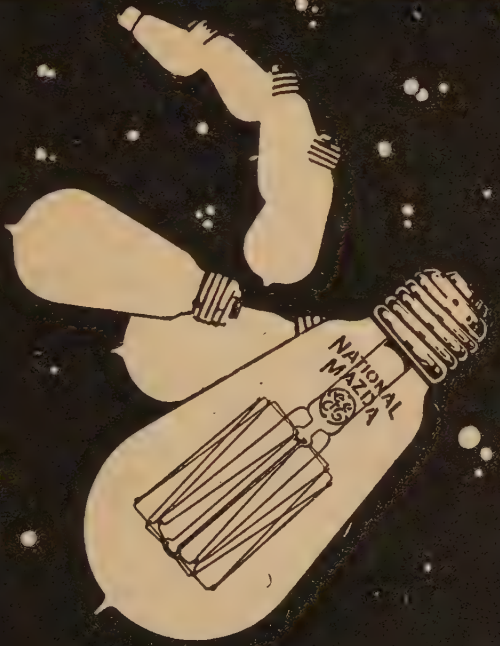
Mazda B Lamps for Ornamental Lighting Service—Round Bulbs.

110 to 125	15	G-18½	122	1.54	Medium Screw
	25	G-18½	212	1.48	" "
	25	G-25	228	1.38	" "
	40	G-25	378	1.33	" "

Tubular Bulbs.

110 to 125	25	T-10	222	1.41	Medium Screw
	40	T-8	362	....	" "

NATIONAL



National Mazda etched on the bulb of a lamp is a guaranty of the best for any use that requires the most light of the right kind at the least expense in the hardest service. NATIONAL LAMP WORKS of General Electric Co., Nela Park, Cleveland.

MAZDA·LAMPS

Mazda B Lamps for Sign Lighting Service—Straight Side Bulbs.

Volts	Watts	Bulb	Lumens	Watts per Sph. C.P.	Base
11 to 12½	5	S-14	45	1.39	Medium Screw
55 to 65	5	S-14	38	1.67	" "
110 to 125	10	S-14	70	1.79	" "

Mazda B Lamps for Electric Street Railway Service—Straight Side Bulbs.

Five Lamps Used in Series on 525, 550, 575, 600, 625 and 650 Volts.

525 to 650	23	S-19	†208	1.49	Medium Screw
	36	S-19	†342	1.44	" "
	56	S-21	†565	1.33	" "
	94	S-24½	†975	1.28	" "

†The lumens given cover only lamps for use 5 in series on 575 volts. The lumens for other lamps are in proportion to the volts.

Mazda C Lamps for Street Lighting Service—Straight Side Bulbs.

Amp.	C. P.				
6.6	60	S-24½	600	1.03	Mogul Screw
	80	S-24½	800	.95	" "
	100	S-24½	1000	.90	" "
	Pear Shape Bulbs.				
	250	PS-35	2500	.78	" "
	400	PS-35	4000	.78	" "
	600	PS-40	6000	.78	" "

Mazda C Lamps for Compensator Street Lighting Service—Pear Shape Bulbs.

15	400	PS-40	4000	.70	Mogul Screw
20	600	PS-40	6000	.67	" "
	1000	PS-40	10000	.65	" "

Mazda B Lamps for Train Lighting Service—Straight Side Bulbs.

30 to 34	10	S-17	85	1.37	Medium Screw
	15	S-17	125	1.31	" "
	*15	S-17	125	1.54	" "
	20	S-17	175	1.29	" "
	25	S-17	250	1.29	" "
	50	S-19	500	1.24	" "

*For cab lighting service.

60 to 65	15	S-17	125	1.38	" "
	25	S-17	250	1.36	" "
	50	S-19	500	1.24	" "
	Round Bulbs.				
30 to 34	10	G-18½	85	1.44	" "
	15	G-18½	125	1.38	" "
	25	G-18½	250	1.36	" "
	50	G-30	500	1.22	Med. Sc. Skirted

ROUND BULBS (Continued)

Volts	Watts	Bulb	Lumens	Watts per Sph. C.P.	Base
60 to 65	15	G-18½	125	1.44	Medium Screw
	25	G-18½	250	1.42	" "
	50	G-30	500	1.22	Med. Sc. Skirted

Mazda C Lamps for Locomotive Headlight Service—Round Bulbs.

30 to 34	100	G-25	1570	.80	Medium Screw
	150	G-25	2520	.75	" "
	250	G-30	4500	.70	" "

Daylight Mazda Lamps for Standard Lighting Service—Pear Shape Bulbs.

110 to 125	75	PS-22	600	....	Medium Screw
	100	PS-25	875	....	" "
	150	PS-25	1400	....	" "
	200	PS-30	2000	....	" "
	300	PS-35	3360	....	Mogul Screw
	500	PS-40	5600	....	" "

Mazda B Lamps for Country Home Lighting Service—Straight Side Bulbs.

28—32	5	S-14	44	1.44	Medium Screw
	10	S-17	92	1.37	" "
	20	S-17	195	1.29	" "
	40	S-19	406	1.24	" "

Mazda C Lamps for Country Home Lighting Service—Pear Shape Bulbs.

28—32	50	PS-20	740	.85	Medium Screw
	75	PS-22	1180	.80	" "
	100	PS-25	1680	.75	" "

Mazda C Lamps for Motion Picture Projection Service—Tubular Bulbs.

28—30	600	T-20	15700	.48	Mogul Screw
	900	T-20	24600	.46	" "

Mazda C Lamps for Flood Lighting Service—Round Bulbs.

110 to 125	250	G-30	3140	1.00	Medium Screw
	500	G-40	7500	.84	Mogul Screw

Mazda C Lamps for Stereopticon Service—Tubular Bulbs.

6 and 12	72	T-10	1290	.70	Medium Screw
	108	T-10	2020	.67	" "
28—30	300	T-16	6850	.55	" "
110 to 125	300	T-16	5800	.65	Medium Screw
	600	T-20	13000	.58	Mogul Screw
	1000	T-20	24200	.52	" "

Round Bulbs.

110 to 125	100	G-25	1400	.90	Medium Screw
	250	G-30	4500	.70	" "
	400	G-30	8100	.62	" "

1

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Mazda B Lamps—Comparative Sizes—See page 280.

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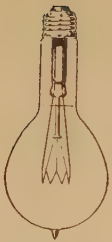

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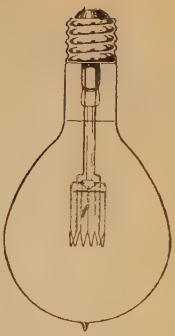

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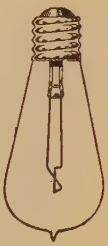

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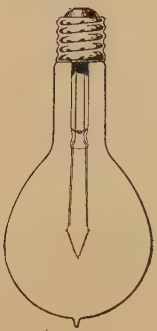

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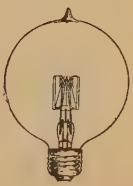

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Mazda C Lamps—Comparative Sizes—See page 280-281.

MAZDA LAMP VARIATIONS

	% Change in Voltage		% C. P. Mazda B (Vacuum)		% Watts Mazda B (Vacuum)		% C. P. Mazda C (Gas Filled)		% Watts Mazda C (Gas Filled)
Increase	10	Increase	39.3	Increase	16.3	Increase	36.3	Increase	15.9
	9		35.0		14.6		32.3		14.3
	8		30.7		12.9		28.4		12.7
	7		26.6		11.3		24.6		11.2
	6		22.6		9.7		20.8		9.5
	5		18.6		8.0		17.2		7.9
	4		14.7		6.4		13.6		6.2
	3		10.9		4.8		10.1		4.7
	2		7.2		3.2		6.6		3.1
	1		3.6		1.6		3.3		1.6
	Normal		0		0		0		0
Decrease	1	Decrease	3.5	Decrease	1.6	Decrease	3.3	Decrease	1.6
	2		6.9		3.1		6.4		3.0
	3		10.2		4.7		9.5		4.6
	4		13.4		6.2		12.5		6.0
	5		16.6		7.8		15.5		6.5
	6		19.7		9.3		18.2		9.0
	7		22.7		10.9		21.0		10.4
	8		25.6		12.4		23.8		12.0
	9		28.5		13.9		26.4		13.3
	10		31.3		15.4		29.0		15.0

KEY TO ILLUSTRATIONS ON PAGES 370 AND 371.

MAZDA B LAMPS (Vacuum Lamps).

See cuts on page —?

Fig. 1.—S-19 Bulb. 40 and 50 watts. 110 to 125 volts. Standard lighting service.

Fig. 2.—S-19 Bulb. 25 and 50 watts. 110 to 125 volts. Mill type, standard lighting service.

Fig. 3.—S-19Bulb. 25 and 50 watts. 220 to 250 volts. Standard lighting service.

Fig. 4.—G-25 Bulb. 25 and 40 watts. 110 to 125 volts. Ornamental lighting service.

Fig. 5.—S-14 Bulb. 10 watts. 110 to 125 volts. Sign lighting service.

Fig. 6.—T-10 Bulb. 25 watts. 110 to 125 volts. Ornamental lighting service.

Fig. 7.—S-19 Bulb. 23 and 36 watts. Electric street railway service.

Fig. 8.—G-18½ Bulb. 15 and 25 watts. 30 to 34 and 60 to 65 volts. Train lighting service.

Fig. 9.—S-19 Bulb. 40 watts. 28—32 volts. Country home lighting service.

MAZDA C LAMPS (Gas Filled Lamps).

See cuts on page —?

Fig. 10.—PS-20 Bulb. 50 watts. 110 to 125 volts. White Mazda lamps for standard lighting.

Fig. 11.—PS-25 Bulb. 100 and 150 watts. 110 to 125 volts. Standard lighting service.

Fig. 12.—PS-40 Bulb. 500 watts. 110 to 125 volts. Standard lighting service.

Fig. 13—T-20 Bulb. 600 and 900 watts. 28—30 volts Motion picture service.

Quality and Service—

these are the prime considerations in the selection and purchase of any product.

When you buy WESTINGHOUSE MAZDA LAMPS you obtain a product with a well-known reputation for service and dependability, the result of adhering rigidly to high standards in every step of their manufacture.

But not only do you get a high quality product in

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you also secure, without charge, the services of our illuminating engineers in any lighting problem, no matter how large or how small it is.

We have in this way helped innumerable industrial plants to put their lighting on an efficient, paying basis.

Westinghouse Lamp Company

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Sales Offices and Warehouses Throughout the Country

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Fig. 14.—G-25 Bulb. 100 and 150 watts. 30 to 34 volts. Locomotive headlight.
Fig. 15.—S-24½ Bulb. 60, 80 and 100 c.p., 6.6 amperes. Street lighting service.
Fig. 16.—PS-25 Bulb. 100 watts. 28—32 volts. Country home lighting service.
Fig. 17.—PS-35 Bulb. 250 C.P., 6.6 amperes. Street lighting service.
Fig. 18.—G-30 Bulb. 250 and 400 watts. 110 to 125 volts. Stereopticon service.

For other Mazda Lamp Data see pages 366 to 372.

COOPER HEWITT LAMPS
(Mercury Vapor)
Direct Current

Type	Amps.	Volts	Watts	Length of Tube	Mean. Hem. C. P.	Watts per C. P.
L	2	110 range	220	35 in.	360	.61
P	3.5	110 range*	385	50 in.	850	.45
PP	3.5	220 range	770	2-50 in.	1500	.51

Alternating Current (25-40-60 Cycles)

F	3.8	110 range†	430	50 in.	950	.45
E	2	110 range‡	200	35 in.	360	.56

*Two in series for 220 V. ranges.
†Or 220 V. range.
‡And 220 V. range.

Power Factor, 85 Per Cent.

The quality of the Cooper Hewitt mercury vapor lamp is such that the light seems to have a magnifying effect, tending to produce sharp vision of objects in minute detail.

The Mercury Vapor Lamp, better known as the Cooper Hewitt Lamp, has been improved greatly during the last few years. The lighting is now entirely automatic, and the lamps are made to operate on either D. C. or A. C. circuits. The same lamp is not made to operate on both.

The type P. Double P, and L lamps operate on D. C.; the type F and E lamps operate on A. C. and are entirely automatic.

The P, Double P, and the F lamps are the standard lamps, being one inch in diameter and 50 inches long, equipped with suitable reflector and auxiliary device for the most efficient operation.

Twenty-four Hour Daylight for Industry

The ideal lighting for industrial plants is such as will give illumination of daylight quality with perfect diffusion and absence of shadows. It must be adequate for all purposes and low in maintenance cost.

Cooper Hewitt Illumination

has all these virtues—the quality of daylight with none of its limitations and uncertainness.

The color and low intensity of Cooper Hewitt Light makes it easy on the eyes, permitting as high efficiency for night shifts as can be achieved by day shifts.

Cooper Hewitt specialists will suggest an ideal layout for the lighting of any industrial plant. Address our nearest office.

Cooper Hewitt Electric Company

Hoboken New Jersey

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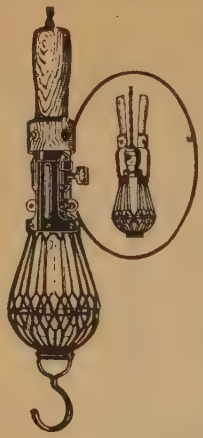
Chicago—215 Fisher Building
Cincinnati—First National Bank Bldg.
Cleveland—Engineers Building

Detroit Ford Building
Los Angeles—Kosse Engineering Corp.
Milwaukee—Security Building

Philadelphia—Drexel Building
Pittsburgh—Westinghouse Building
St. Louis—Central National Bank Bldg.
Syracuse—University Building

CH-1



For Light where Light doesn't ordinarily strike

For electrical contractors, linemen, engineers, etc., in the engine pit, ferreting out "trouble" in the warehouse bin, under machines,—where light is imperative at times but not a necessity at all times use

Flexco Split Handle Portable

Hinges wide open and quickly closes over any lamp socket, ready for instant use as a portable guard without any need of wiring. The cord runs through grooves in the handle. The split, wood handle easily fastens to a Standard Flexco-Lamp Guard and hinges with it as a unit. The hook at the end of the guard convenient for hanging the light where most needed. With the Flexco-Split Handle Portable, it is easy to reach the hard-to-see places.

Are your Lights Unguarded?

Every unguarded electric lamp is liable to theft or breakage, a source of danger from fire and accident. Flexco-Lok Lamp Guards put a guard of steel around each light. You know the delay and annoyance of finding bulbs gone when you want a light. Bulbs cannot be removed or broken if protected by Flexco-Lok guards. Locks and unlocks with patent key provided free with each dozen guards.

FOR SALE BY LEADING DEALERS

Illustrated literature and complete price lists mailed on request. It is cheaper to buy guards than new bulbs.

Dealers not handling our line are invited to write for proposition.

FLEXCO-LOK

Flexible Steel Lacing Company

Also manufacturers of Alligator Steel Belt Lacing

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THE KEY TO SAFETY

Two expensive elements of loss face the lamp user. To stop *breakage* he must use a *guard*, to stop *theft* he must use a *lock*. A guard fastened with wire or set screw cannot stop a thief; nor can a patent socket prevent lamp breakage.

The *Loxon Lamp Guard*, which locks the lamp into a socket with a key, *does this double duty at single cost.*

At Prices Pleasingly Below the Expected

Send for Catalog and Price on our Complete Line

Dreadnaught Portable Lamp Guard

A very strong portable guard made of Bessemer steel, built to withstand hard usage and can be recommended to give unusual service. Has a porcelain keyless socket fitted with spring contact firmly embedded in handle. Takes a 60-Watt Lamp. Metal part copper-plated finish. Made in only one size and finish.

Other Portable Guards Made For Every Known Use

McGILL MFG. CO.

Largest Manufacturers of Lamp Guards In America

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Alternating Current.—A current which flows alternately in opposite directions, similarly to the ebb and flow of a tide. A current whose direction is periodically reversed and whose graph, when plotted, consists of half-waves of equal area on successively opposite sides of a zero line. An alternating current equals the electromotive force divided by the impedance, or

$$I = \frac{E}{Z} = \frac{E}{\sqrt{R^2 + X^2}} = \frac{E}{\sqrt{R^2 + \left(L\omega - \frac{1}{C\omega}\right)^2}}$$

This expression represents Ohm's law for alternating currents.

I = Current of circuit in amperes.
E = Potential of circuit in volts.
Z = Impedance of circuit in ohms.
R = Resistance of circuit in ohms.
X = Reactance of circuit in ohms.
L = Coefficient of self induction in henrys.
C = Capacity of the circuit in farads.
$\omega = 2\pi f$ angular velocity, where
f = the number of cycles per second, or frequency.

Alternator, or Alternating Current Generator. A generator which produces alternating currents, either single-phase or polyphase.

Ammeter. A form of galvanometer, or instrument, in which the value of the current is measured directly in amperes.

An ammeter is a galvanometer with an indicator which moves over a divided scale and indicates, directly, the value of the current flowing through the instrument. In many cases a small but definite fractional part only of the current flows through the ammeter, the remainder flowing through a low resistance shunt. The numbers on the ammeter scale may be made to give the value of the total current including that which flows through the shunt. If desired, the instrument may be provided with several interchangeable shunts of different resistances, so that the instrument may be used to measure large or small currents at

will. In such a case the scale readings must be multiplied by a factor to give the total current, and this factor has a large value for a low resistance shunt and a small value for a high resistance shunt.

Ampere—Unit of Current (I). Its value in ordinary practice may be defined as that quantity of electricity which flows through an ohm of resistance (R) when impelled by one volt (E). The International ampere, as defined by the International Electrical Congress, which met in Chicago in 1893, is: "one-tenth of the unit of current of the c.g.s. system of electromagnetic units, and is represented sufficiently well for practical use by the unvarying current, which, when passed through a solution of nitrate of silver in water and in accordance with an adopted set of specifications, deposits silver at the rate of 0.001118 of a gram per second."

Ampere-Hour. A unit of electrical quantity equal to the quantity of electricity conveyed by one ampere flowing for one hour. A quantity of electricity equal to 3,600 coulombs.

Ampere-Hour Meter. An instrument giving the total time summation of the amperes.

Ampere-Second. A unit of electrical quantity equal to the quantity of electricity conveyed by one ampere flowing for one second. A coulomb. (See Coulomb).

Ampere Turn. A unit of magneto-motive force equal to that produced by one ampere flowing around a single turn of wire.

Angle of Lead of Commutator Brushes. The forward angular deviation from the normal position which must be given to the collecting brushes on the commutator of a continuous-current generator in order to obtain sparkless commutation.

Anode. That electrode by which the current enters an electrode. The positive electrode.

Aperiodic Instrument. An instrument whose indicator comes to rest without any oscillation. A dead-beat instrument.

Apparent Electromotive Force. The e. m. f. apparently acting in a circuit as measured by the drop of pressure due to the resistance of the circuit and the current strength passing through it.

Apparent Power, Volt-Amperes. In an alternating current circuit, the apparent power, or the product obtained by multiplying the volts by the amperes, as read directly from a voltmeter and ammeter.

$\frac{\text{Power}}{\text{Power-factor}}$=apparent power. When the power-factor is unity the apparent power in volt-amperes is equal to watts.

Apparent Resistance. The impedance of an alternating current circuit.

Apparent Watts. The apparent power in an alternating current circuit as distinguished from the real or true power.

Armature. A mass of iron, or other magnetic material, placed on or near the poles of a magnet.

That part of a dynamo, motor or continuous current meter which carries the wires that are rotated in the magnetic field.

Automatic Circuit Breaker. A device for automatically opening a circuit when the current through it exceeds a predetermined value.

Bank of Lamps. A group of electric lamps assembled upon a common frame or structure, and usually employed for the purpose of obtaining a load.

Battery. A number of individual cells connected in series, in multiple, or in series-multiple, and so arranged that they form a single unit.

See Storage Battery.

Bifilar Suspension. Suspension by means of parallel vertical wires, or fibers, as distinguished from suspension by a single wire, or fiber.

Bifilar Winding. The method of non-inductive winding, employed in resistance coils to obviate the effects of self-induction, in which the wire, instead of being wound in one continuous length, is doubled on itself before winding.

Binding Post. A metallic binding screw, rigidly fixed to some apparatus or support, and employed for conveniently making firm electric connections.

Branch Conductor. A conductor placed in a branch, or shunt circuit. A smaller, or circuit conductor, tapping a main.

Bridge, Wheatstone. A device by which an unknown resistance can be determined or measured by comparison with three known resistances.

Brushes of Dynamo Electric Machines. Strips of metal, bundles of wire, wire gauze, slit plates of metal, or plates of carbon, that bear on the commutator of a dynamo, motor or meter for carrying off the current generated by, or for conveying current to, the armature.

Burn Out. The destruction of an armature, or any part of an electric apparatus, by the passage of an excessive current due to short-circuit or other cause.

Busbars. The heavy metallic bars to which dynamo leads are connected and to which the outgoing lines, etc., are connected.

Capacity, Current Carrying. Applied to a wire, this term commonly means the maximum current that the wire can safely carry as determined by the National Electric Code requirements. (See Page 17.) Applied to electrical apparatus, it means the current that the apparatus can carry without damage to itself, or without exceeding a specified temperature rise.

Capacity, Electric. Relative ability of a conductor, or system, to retain an electric charge. See farad.

Carbon Rheostat. An adjustable resistance formed of carbon plates, or powder, whose resistances can be varied by pressure.

Cathode. That electrode by which the current leaves an electrolyte is called the cathode. The negative electrode.

Cell, Electrolytic. A cell or vessel containing an electrolyte in which electrolytic action takes place.

An electrolytic cell is called a voltameter when the value of the current passing is deduced from the weight of the metal deposited.

Center of Distribution. In a system of electrical energy distribution, any point at which the supply current is branched, or radially distributed, to mains, submains, or to translating devices.

Centimeter (1/100 meter). A measure of length in the metric system; equal to 0.3937 inch or one-billionth (.000000001) of a quadrant of the earth. See page 391.

Choke Coil. A coil of high-inductance, used either for limiting the flow of current in an alternating current circuit, or for stopping the flow of current that has been started by some external source of voltage. Commonly employed in connection with lighting arresters.

Circuit. A circuit is a path composed of a conductor, or of several conductors joined together, through which an electric current flows from a given point around the conducting path, back again to its starting point.

Circuit, Closed. A series of conductors joined end to end so as to form an endless chain is said to be a closed circuit. (It may or may not have an electric current passing through it.)

Circuit, Grounded. A circuit in which the conductors

are in contact with the ground, or with some electric conductor leading to the ground, is said to be a grounded circuit (see Ground).

Circuit, Multiple. A compound circuit in which a number of separate sources, or separate electro-receptive devices, or both, have all their positive poles connected to a single positive lead, or conductor, and all their negative poles to a single negative lead or conductor. (See circuit, parallel and shunt.)

Circuit, Open. A circuit, the conducting continuity of which is broken or interrupted.

Circuit, Parallel. A name sometimes applied to circuits connected in multiple. (See circuit, multiple and shunt.)

Circuit, Series. A compound circuit in which the separate sources or the separate electro-receptive devices, or both, are so placed that the current produced in each, or passed through each, passes successively through the entire circuit from the first to the last.

Circuit, Short. See short circuit.

Circuit, Shunt. See shunt circuit.

Circuilar Mil. A unit of area employed in measuring the cross-sectional areas of wires. The area of a circle one mil (.001 inches) in diameter.

The number of circular mils in any wire may be found by squaring (multiplying by itself) the diameter of the wire expressed in thousandths of an inch. The resistance of a copper wire is inversely, and the weight directly, proportional to the circular mils (c.m.). See "Square Mil."

Clockwise Motion. A rotary motion whose direction is the same as that of the hands of a clock, viewed from the front.

Coefficient of Mutual Inductance. The ratio of the electromotive force induced in a circuit to the rate of change of the inducing current in a magnetically associated circuit.

Coefficient of Self-Induction. The ratio in any circuit of the flux induced by and linked with a current, to the strength of that current.

Coil, Electric. A convolution, or turn, of insulated wire through which an electric current may be passed. A number of turns of wire, or a spool of wire, through which an electric current may be passed.

Collector Rings. The metallic rings on an alternating current dynamo, or motor, which are connected to the armature wires and over which the brushes slide.

Commutator. A device for changing the direction

of electric currents, usually used for changing alternating into continuous currents.

Commutator Segments. The insulated bars composing a commutator.

Condenser. A device for storing an electric charge or for increasing the capacity of an alternating current circuit. A capacity. As commercially constructed, a condenser consists of two plates or two sets of plates, brought near each other but electrically separated by an insulator termed a dielectric.

Conductivity, Electric. The reciprocal of electrical resistance $= \frac{1}{R}$ The unit is sometimes written as *mho* (ohm spelled backwards).

Conductor. Any substance which will permit the so-called passage of an electric current.

Conduit, Electric. An enclosed space, either single or provided with a number of separate spaces called ducts, employed for the reception of electric wires or cables.

Connecting Sleeve. A metallic sleeve employed as a connector for readily joining the ends of two or more wires.

Converter. A secondary generator for transforming alternating into continuous currents or vice versa, consisting of an alternating current machine whose armature winding is connected with a commutator; or a continuous current machine, whose armature is tapped at symmetrical points and connected to collector rings, so that, when the armature runs, it is an alternator on one side and a continuous current machine on the other. A rotary transformer.

Corrosion, Electrolytic. A term frequently employed to describe the disintegration of metals due to electrolytic action.

Coulomb. The practical unit of electric quantity. The quantity of electricity that passes in one second through a circuit conveying one ampere.

Counter Electromotive Force. An opposing electromotive force which resists the current in a circuit. It is like back pressure in hydraulics. Thus, to find the available E. M. F., or the resulting current against a resistance where there is a counter E. M. F., the counter E. M. F. must be deducted. For example: Suppose a storage battery with a resistance of .02 ohm and a C. E. M. F. of 15 volts, and you wish to charge it with

a dynamo which gives an E. M. F. of 20 volts at the battery binding posts. There are $20 - 15 = 5$ volts working through a resistance of .02 of an ohm with consequently a current of 250 amperes. The impressed 1,250 watts, as might perhaps be supposed. It is obvious that the C. E. M. F. has acted as a true resistance. In the above case $5 \times 250 = 1{,}250$ watts were wasted in overcoming the resistance of the storage battery and the remaining 3,750 watts were stored up in the chemical changes which they brought about in the active material of the storage battery.

Cross, Electric. A connection, generally metallic, accidentally established between two conducting lines. A defect in a telegraph, telephone, electric power, or other circuit, caused by two wires coming into contact by crossing each other.

Current. This word and also the word "flow" arose from a misconceived analogy between the electric current and a current of liquid in a tube. This term will be used in its accepted sense.

The quantity of electricity per second, which passes through any conductor or circuit, when the flow is uniform. The rate at which a quantity of electricity flows or passes through a circuit. The ratio expressed in terms of electric quantity per second, existing between the electromotive force causing a current and the resistance which opposes it.

The unit of current, or the ampere, is equal to one coulomb per second. See ampere, and coulomb.

The word current must not be confounded with the mere act of flowing; electric current signifies rate of flow, and always supposes an electromotive force to produce the current, and a resistance to oppose it.

The electric current is assumed to flow out from the positive terminal of a source, through the circuit and back into the source at the negative terminal. It is assumed to flow into the positive terminal of an electro-receptive device such as a lamp, motor, or storage battery, and out of its negative terminal; or, in other words, the positive pole of the source is always connected to the positive terminal of the electro-receptive device.

The current that flows or passes in any circuit is, in the case of continuous current, equal to the electro-

motive force, or difference of potential, divided by the resistance, as:

$$I = \frac{E}{R}; \text{ for alternating current } I = \frac{E}{Z}$$

The flow of an electric current may vary in any manner whatsoever.

A current which continues flowing in the same direction no matter how its strength may vary, is called a continuous current, or sometimes a direct current, analogous to the flow of a river. If the strength of such a current is not constant, it is a varying continuous current. A regularly varying continuous current is called a pulsatory or pulsating current, analogous to the flow of blood in the veins. A current which alternately flows in opposite directions, no matter how its strength may vary, is called an alternating current. This may be periodic or non-periodic.

Current, Alternating. See alternating current.

Current, Continuous. An electric current which flows in one and the same direction. A steady, or non-pulsating current. (See Direct Current.)

Current, Determination of, from Wattage Rating. The rated current may be determined as follows: If P = rating in watts, or apparent watts, if the power-factor be other than 100 per cent, and E = full-load terminal voltage, the rated current per terminal is:

$I = \frac{P}{E}$ in a continuous current, or single-phase apparatus.

$I = \frac{1}{\sqrt{3}} \frac{P}{E}$ in three-phase apparatus.

$I = \frac{1}{2} \frac{P}{E}$ in two-phase four-wire apparatus.

Current Strength. In a continuous current circuit the quotient of the total electromotive force divided by the total resistance. The time-rate-of-flow in a circuit expressed in amperes, or coulombs per second. In an alternating current the quotient of the total electromotive force divided by the impedance.

Current Transformer. A stationary device by which the current strength of one alternating current circuit may be changed in a definite ratio, to a current strength in a secondary or associated circuit through the action of electro-magnetic induction.

Cut-Out. A device for removing an electro-receptive device, or loop, from the circuit of an electric source. A porcelain fuse block.

Cycle. A succession of events which periodically recur, reckoning from any stage of the disturbance to the moment at which that stage next occurs. A complete recurrence of any periodic change. One complete periodic oscillation of an alternating current wave. Two alternations; 60 cycles per second equals 120 alternations per second, or 7,200 per minute.

Dead-Beat Galvanometer. An aperiodic galvanometer, or one whose needle comes quickly to rest instead of repeatedly swinging to-and-fro. A heavily damped galvanometer.

Dead Ground or Grounding. Such a grounding as will ensure a ground of negligible resistance.

Density of Current. The quantity of current that passes per unit of area of cross section in any part of a circuit.

Density of Field. The quantity of magnetic flux that passes through any field per unit of area of cross section.

Dielectric. Any substance which permits electrostatic induction to take place through its mass.

The substance which separates the opposite coatings of a condenser is called the dielectric. All dielectrics are non-conductors.

All non-conductors, or insulators, are dielectrics but their dielectric power is not exactly proportional to their non-conductive power.

Substances differ greatly in the degree or extent to which they permit induction to take place through or across them. Thus, a certain amount of inductive action takes place between the insulated metal plates of a condenser across the layer of air between them.

A dielectric may be regarded as pervious to rapidly reversed periodic currents, but impervious to continuous currents. There is, however, some slight conduction of continuous currents.

Direct Current. A current whose direction is constant, as distinguished from an alternating current. A unindirectional current. It embraces both pulsating and continuous current. Erroneously applied to continuous current only.

Drop. A word frequently used for drop of potential or electromotive force. The fall of potential which takes place in an active conductor.

Drum Armature. An armature whose coils are wound longitudinally over the surface of a cylinder or drum.

Dynamo. A rotating machine for the conversion of mechanical energy into electrical energy by electromagnetic induction. A term used to denote any kind of a generator except a magneto. (See Generator.)

Earth Plates, Ground Plates. Plates of metal, buried in the earth or in water, arranged to be connected to electric wires for the purpose of grounding the circuit.

Earth Return. That portion of a grounded circuit in which the earth forms the conducting path.

Electricity Meter. An apparatus used for the purpose of measuring the quantity of electricity, or electrical energy. Attention is called to the difference between "meter" and "instrument." The latter term is used to designate that type of apparatus which indicates, i. e., a meter measures and an instrument indicates

Electrification. Applied scientifically: The act of charging with electricity. The state of being charged with electricity. As applied in commercial practice to railroads, factories, etc.: Equipping with motors for electric drive.

Electrode. Either of the terminals of an electric source. Either of the terminals of an electric source that are placed in a solution in which electrolysis is taking place.

Electrolysis. Chemical decomposition effected by means of an electric current. The decomposition of the molecule of an electrolyte into its ions or radicals. Electrolytic decomposition.

Electrolyte. Any compound liquid which is separable into its constituent atoms or radicals by the passage of electricity through it. The exciting liquid in a voltaic cell.

Electromagnet. A mass of iron which is magnetized by current through a coil of wire wound around the mass but insulated therefrom.

Electromotive Force. The force which starts and maintains a current of electricity in a conductor; commonly measured in terms of volts. Abbreviated e. m. f. An electromotive force of one volt (E) will force one ampere (I) of current through one ohm of resistance (R).

Farad. The practical unit of electric capacity. Such a capacity of a conductor, or condenser, that one coulomb of electricity is required to produce therein

a difference of potential of one volt. A condenser of one farad capacity, if charged to two volts, will contain two coulombs; if to 100 volts, 100 coulombs, etc.

Field. A term used for either electro-static or electro-magnetic influences. The space occupied by electric or magnetic lines of force.

Field, Magnetic. The region of magnetic influence surrounding the poles of a magnet.

Field Magnets. The magnets which produce the magnetic field, or flux, in which the armautre of a dynamo, motor, or meter rotates.

Field of Force. The space traversed by electrostatic or magnetic flux. An electrostatic or magnetic field.

Frequency of Alternation. The number of cycles or periods executed by an alternating current in unit time. The periodicity. The two standard frequencies are now 25 and 60 cycles per second.

Fundamental Units. The units of length, time and mass, to which all other quantities can be referred. Units of length, time and mass, as distinguished from their derivations or derived units. The fundamental electrical units are the volt, ampere and ohm.

Fuse, Electric. A conductor designed to melt or fuse at a certain value of current and time and by so doing to rupture the circuit.

Galvanometer. An apparatus for measuring the strength of an electric current by the deflection of a magnetic needle. A current measurer.

The galvanometer depends for its operation upon the fact that a conductor, through which an electric current is flowing, will deflect a magnetic needle placed near it. This deflection is due to the magnetic field caused by the current.

The needle is deflected by the current from a position of rest, either in the earth's magnetic field or in a field from a permanent magnet or electromagnet. In the first case, when in use to measure a current the plane of the galvanometer coils must coincide with the planes of the magnetic meridian. In the other case, the instrument may be used in any position in which the needle is free to move.

Galvanometer Shunt. A low resistance connected across the terminals of a galvanometer in parallel with its windings.

Generator. A dynamo-electric machine. One which transforms mechanical into electrical power. (See Alternator; see Dynamo.)

Gram. The unit of mass or weight in the metric

system, equal to 15.43235 grains. The mass of a cubic centimeter of water at the temperature of its maximum density, 4° Centigrade.

Ground. A general term for the connection of a conductor to the earth.

Ground-return. A general term used to indicate the use of the ground, or earth, for part of an electric circuit. The earth, or ground, which forms part of the return path of an electric circuit.

Ground-wire. The wire, or conductor, leading to, or connected with, the ground, or earth, in a grounded circuit.

Ground Circuit. A circuit in which the ground forms part of the path through which the current passes.

Horse Power. A commercial unit of power, activity, or rate of doing work. A rate of doing work equal to 33,000 pounds raised one foot per minute, or 550 pounds raised one foot per second. A rate of doing work equal to 4,562 kilograms raised one meter per minute. Such a rate of doing electrical work as is equal to 746 watts, or 746 volt-coulombs per second. The horse-power-hour is a unit of work equal to the work done by one horse power acting for one hour = 1,980,000 foot-pounds.

The horse power and horse-power-hour are equal to 746 watts and watthours, respectively. Based on this relation, the horse power may be said to be approximately ¾ of a kilowatt, or conversely, a kilowatt is equal to approximately 1⅓ horse power.

Induction, Mutual. Induction produced by two neighboring circuits on each other by the mutual interaction of their magnetic fields.

Induction, Self. Induction produced on a circuit, at the moment of starting or stopping the currents therein, by the induction of the current on itself.

Insulation Resistance. The resistance existing between a conductor and the earth, or between two conductors in a circuit through insulating materials lying between them. A term applied to the resistance of the insulating material of a covered wire or conductor to an impressed voltage tending to produce a leakage of current. The resistance of any insulation.

Interior Conduit. A conduit in the walls or floors of a building, provided for accommodating electric conductors.

Joint Resistance. The combined resistance of a number of parallel connected resistances. (See Resistance.)

Joule. A volt-coulomb or unit of electric energy or

work. The amount of electric work required to raise the potential of one coulomb of electricity one volt. Joules = W = work done = watts × seconds.

It is the work done, or heat generated, by a watt in a second.

Joule's Laws of Heating. In any given conductor the heat developed by an electric current in any given time varies directly as the square of the current, and as the resistance, that is, the heat varies as I^2R. Also since the total heat varies as the time, the total heat is

$$I^2RT$$

or, if expressed in calories

$$I^2RT$$

Kilometer. (See Metric Weights and Measures.)
1 Kilometer = 1000 meters = 3281 feet = 0.6213 mils.

Kilovolt. One thousand volts.

Kilowatt. One thousand watts.

Kilowatthour. The amount of work equal to that performed by an activity of one kilowatt maintained steadily for one hour. An amount of work equal to 3,600,000 joules. One thousand watthours.

1 kw. hour =
- 3.12 British thermal units.
- 2,654,536 foot-pounds.
- 3.53 pounds of water evaporated at 212° F.
- 22.8 pounds water raised from 62° to 212° F.
- 0.235 pounds carbon oxidized at 100 per cent off.

Load. The work placed upon any machine, apparatus or system.

Load, Artificial. A load purposely created, which is intended to replace an equivalent, but not controllable load, as found on the consumer's premises.

Load, Normal. A load as found at the consumer's premises under normal, or usual, conditions for the time under consideration; also that load for which any apparatus is intended to be used.

Load Transformer. Any transformer designed to carry an appreciable electrical load. In laboratory work, or in connection with tests, this term is commonly used to distinguish these transformers from those small transformers called instrument transformers, used to furnish instruments, or meters, with relatively small currents, or voltages.

Low-Tension. A relative term used to designate a

winding or conductor of less voltage than that with which it is related or compared. For electric light, heat or power, a voltage less than 550.

Lumen. The quantity of light required to illuminate one sq. foot of surface of one foot-candle intensity—one foot-candle intensity is the illumination on a surface one foot from a light source of one candle-power.

Magnet. Any body producing magnetic flux. A body possessing the power of attracting the unlike pole of another magnet, or of repelling the like pole, or of inducing magnetism in magnetizable bodies.

Magnet Coil. A coil of insulated wire surrounding the core of an electromagnet, through which the magnetizing current is passed.

Magnetic Circuit. The path through which magnetic flux passes.

Magnetic Field. The region of magnetic influence surrounding the poles of a magnet. The space or region traversed by magnetic flux in which a magnetized needle, free to move, will assume a definite position.

Magnetism. That property or condition of matter which accompanies the production of magnetic flux.

Megohm. One million ohms.

Meter, Electricity. See "Electricity Meter."

Meter (linear measure). (See Metric Weights and Measures). 1 meter = 39.3704 inches = 3.281 feet. Practically, 1 meter = 3 feet 3⅓ inches.

METRIC WEIGHTS AND MEASURES.

Linear Measures.

1 meter = 39.3704 inches = 3.281 feet = 1.094 yards.
centimeter (1/100 meter) = 0.3937 inch.
1 millimeter (mm.) = 0.03937 inch = 39.37 mils.
1 inch = 25.3997 millimeters = 0.083 foot = 2.54 centimeters.
1 kilometer = 1,000 meters or 3,281 feet = 0.6213 mile.
For the purpose of memory, a meter may be considered as 3 feet, 3⅓ inches.

Surface Measures.

centare (1 square meter) = 1,550 square inches = 10,764 square feet.
are (100 equare meters) = 119.6 square yards.
1 square centimeter = 0.155 square inch = 197,300 circular mils.
1 square millimeter = 0.00155 square inch = 1973 circular mils.

1 square inch = 6.451 square centimeters = 0.0069 square foot.
1 square foot = 929.03 square centimeters = 0.0929 square meter.

Weights.

Milligram (1-1000 gram) = 0.0154 grain.
Centigram (1-100 gram) = 0.1543 grain.
Decigram (1-10 gram) = 1.5432 grains.
Gram = 15.432 grains.
Decagram (10 grams) = 0.3527 ounce.
Hectogram (100 grams) = 3.5274 ounces.
Kilogram (1,000 grams) = 2.2046 pounds.
Myriagram (10,000 grams) = 22.046 pounds.
Quintal (100,000 grams) = 220.46 pounds.
Millier or tonne (ton) (1,000,000 grams) = 2,204.6 pounds.

Measures of Volume.

Milliliter (1-1000 liter) = 0.061 cubic inch.
Centiliter (1-100 liter) = 0.6102 cubic inch.
Deciliter (1-10 liter) = 6.1023 cubic inches.
Liter = 1,000 cu. cm. = 61.023 cubic inches.
Hectoliter (100 liters) = 2.838 bushels.
Kiloliter (1,000 liters) = 1,308 cubic yards.

Liquid Measures.

Milliliter (1-1000) = 0.0338 fluid ounce.
Centiliter (1-100 liter) = 0.338 fluid ounce.
Deciliter (1-10 liter) = 0.845 gill.
Liter = 1.057 quart = 0.2642 gallon.
Decaliter (10 liters) = 2.6418 gallons.
Hectoliter (100 liters) = 26.418 gallons.
Kiloliter (1,000 liters) = 264.18 gallons.

Microfarad. One-millionth of a farad.

Michrom. One-millionth of an ohm.

Mil. A unit of length equal to one one-thousandth of an inch, used in measuring the diameter of wire.

Mil-foot. A resistance standard consisting of a foot of wire, or other conducting material, one mil in diameter. A standard of comparison of resistivity, or conductivity, of wires.

Milli-ampere. One-thousandth of an ampere.

Millimeter (mm.) (1-1000 meter). 1 millimeter = 0.039737 inch. (See Metric Weights and Measures.)

Milli-volt. One-thousandth of a volt.

Motor. An electric motor is an apparatus for transforming electrical energy into mechanical energy by means of continuously supplying a system of electrical conductors with an electric current which causes a magnetic force to act between the conductors carrying it and the magnetic field, or fields, thereby producing continuous relative motion between the conductors and the magnetic fields.

Motor-Generator. Motor and generator on the same shaft, for changing alternating current to continuous, and vice versa, or changing current of high voltage and low intensity to current of low voltage and high intensity and vice versa.

Motor, Induction. An induction motor is a rotating machine which transforms electrical power in alternating current into mechanical power. It consists of two essential parts, namely, the primary or field, to which the line is connected, and the secondary, or armature, in which currents are induced by the action of the primary. Either of these parts may be the revolving member, but, generally, the field is stationary and the armature revolves, giving rise to the names stator and rotor, respectively.

Multiple Series Circuit. A circuit in which a number of separate sources, or receptive devices, or both, are connected in a number of separate groups in series, and these separate groups subsequently connected in multiple. A multiple of series.

Multiple Windings. Independent windings symmetrically disposed upon the same armature, insulated from each other, but brought to different segments of the commutator.

Negative Conductor. The conductor connected to the negative terminal of an electric source.

Normal Current. The current strength at which a system or apparatus is designed to be operated.

Ohm. The unit of electrical resistance; one ohm is that resistance (R) through which one ampere of current (I) will flow at a pressure of one volt (E). Defined by the International Electrical Congress, which met in Chicago, in 1893, as "a resistance equal to 10^9 units of resistance in the c.g.s. system of electromagnetic units, represented by the resistance offered to an unvarying electric current by a column of mercury at the temperature of melting ice, 14,4521 grams in mass, of a constant cross-sectional area and a length of 106.3 cm."

Ohm's Law. The law of non-varying current

strength in a circuit not subject to variation stated as follows: The strength of a continuous current is directly proportional to the difference of potential or electromotive force in the circuit and inversely proportional to the resistance of the circuit, i. e., is equal to the quotient arising from dividing the electromotive force by the resistance.

Ohm's law is expressed algebraically thus:

$$I = \frac{E}{R}; \text{ or } E = IR; \text{ or } R = \frac{E}{I}$$

If the electromotive force is given in volts, and the resistance in ohms, the formula will give the current strength, directly in amperes.

The current in amperes is equal to the electromotive force in volts divided by the resistance in ohms.

The electromotive force in volts is equal to the product of the current in amperes and the resistance in ohms.

The resistance in ohms is equal to the electromotive force in volts divided by the current in amperes.

The quanity of electricity in coulombs is equal to the current in amperes multiplied by the time in seconds.

Oscillating Current. An oscillatory current. A periodically alternating current of diminishing amplitude.

Parallel Circuit. A term sometimes used for multiple circuit.

Phase Wire. Wires leading from the collector rings (neutral excluded), terminals from transformers or any other alternating current apparatus are commonly called phase wires.

Polarity. The possession of poles, or of opposite properties, at opposite ends. The condition of electric or magnetic differentiation between properties of electric or magnetic flux depending on, and inherent in, the direction of such flux.

Positive Charge. According to the double-fluid hypothesis, a charge of positive electricity. According to the single-fluid hypothesis, any excess of an assumed electric fluid. A charge of electricity having a positive potential.

Positive Lead. In a system of parallel distribution, a lead connected with the positive generator terminal, or with the positive bus-bars.

Positive Pole. That pole of an electric source out of which the current is assumed to flow.

Positive Wire. The wire connected with the positive pole of a source.

Potential, Electric. The power of doing electric work. Electric level. Voltage. Electric pressure.

Potential Transformer. A term frequently employed to designate a voltage transformer when designed primarily for use with meters or instruments (see Voltage Transformer).

Power. Rate of doing work, expressible in watts, joules-per-second, foot-pounds per hour, etc. Activity. The total amount of work done is independent of time, that is to say, the total work is the same whether it is done in one minute or in one year. But when various amounts of work, done in different times, are to be compared with a common standard of power, the element of time must be considered.

Similarly in the electrical circuit; the total number of joules of work done is independent of the time, but when there are several circuits, the work of each of which is to be compared with a standard, the element of time in which this work is done must be considered.

Power-Factor. This is the ratio of the power (average value of the product of volts and amperes as measured by a wattmeter) to the volt-amperes. The power-factor of an alternating current supply indicates the ratio of actual watts to apparent watts which may be delivered. The apparent watts are equal to the product of the volts and amperes, but owing to possible "phase displacement," the power delivered may be actually less than the apparent power. The power-factor is usually expressed as a decimal fraction. If a pressure of 10 volts delivers two amperes at a power-factor of 0.8 (or 80 per cent.) the apparent power is 20 watts, while the actual power is 0.8×20 or 16 watts.

Primary. That winding of an induction motor or of a transformer which directly receives power.

Primary Coil of Transformer. That coil of transformer on which the primary electromotive force is impressed. The coil which receives energy prior to transformation.

Primary Currents. Currents flowing in a primary circuit, as distinguished from currents flowing in a secondary circuit.

Ratio of Transformation. The ratio between the electromotive force, or current, produced at the secondary terminals of an induction coil or transformer,

and the electromotive force, or current, impressed on the primary terminals.

Reactance, Inductive. The inductance of a coil or circuit multiplied by the angular velocity of the sinusoidal current passing through it, or expressed by the formula $x = 2\pi fL = \omega L$, where $\omega = 2\pi f$, and f is the frequency in cycles per second, and L is the coefficient of self-induction.

A quantity whose square added to the square of the resistance gives the square of the impedance, in a simple harmonic current circuit (see Alternating Current).

Residual Magnetism. The magnetism remaining in the core of an electromagnet after the removal of a magnetizing current. The small amount of magnetism retained by soft iron when removed from all external magnetic flux.

Resistance. The quality of an electrical conductor by virtue of which it opposes an electric current. The unit of resistance is the ohm.

Resistance (R) is that attribute of a conductor or of a circuit which determines the strength of the electric current that can be sent through the conductor or the circuit, between the opposite ends of which a constant difference of potential is maintained, as shown by Ohm's law. The resistance of a given conductor is always constant at the same temperature, irrespective of the strength of current flowing through it or the electromotive force of the current, and the resistance of a given conductor increases as the length of the conductor increases; that is, the resistance of a conductor is directly proportional to its length. Also, the resistance of a conductor varies inversely as its sectional area, or the resistance of a conductor of circular cross section is inversely proportional to the square of its diameter.

The combined resistance of several resistances in parallel may be found by taking the reciprocal of the sum of the reciprocals of the individual resistances of each branch circuit. This law follows from the law of conductance, which states that the combined conductance of a parallel branch circuit is equal to the sum of the conductances of the branches, and since the resistance is equal to the reciprocal of the conductance, the reciprocal law holds true, as above stated.

Second. The unit of time. The time of one swing of a pendulum, swinging 86464.09 times per day.

Secondary. (See Secondary Winding.)

Secondary Battery. (See Storage Battery.)

Secondary Winding. That winding of an induction motor or of a transformer which receives power from the primary by induction.

Note.—The terms "high-tension winding" and "low-tension winding" are suitable for distinguishing between the windings of a transformer where the relations of the apparatus to the source of power are involved.

Self-induced Current. A current induced in a circuit on the opening or closing of the circuit, or by changes in the current strength in it.

Self-induction. Induction produced in a circuit by the induction of the current on itself at the moment of starting, changing, or stopping the current therein.

Series Circuits. A circuit in which a number of separate sources, or separate electro-receptive devices, or both, are so connected that whatever current passes through one passes through all.

Series Multiple Circuit. A compound circuit in which a number of separate sources, or separate electro-receptive devices, or both, are connected in a number of separate groups in multiple, and these separate groups subsequently connected in series. A series of multiples.

Short Circuit. A shunt or by-path of negligible or comparatively small resistance, placed around any part of an electric circuit, through which so much of the current passes as to virtually cut out the parts of the circuit to which it acts as a shunt. A fault in an electric circuit or apparatus such that the current follows a by-path. An accidental direct connection between the mains or main terminals of a dynamo or system producing a heavy overload of current. To accidentally produce a short circuit.

Shunt. An additional path established for the passage of an electric current or discharge.

Shunt Circuit. A derived circuit. A branch, or additional circuit, provided in any part of a circuit, through which the current branches or divides, part flowing in the original circuit and part through the new branch or shunt. A circuit for diverting or shunting a portion of the current.

Single-phase, Uniphase, Monophase. Pertaining to ordinary alternating currents in a simple alternating current system as distinguished from polyphase currents.

Solenoid. A cylindrical coil or wire whose convolutions are circular. An electromagnetic helix. Without any central bar of iron or steel a spiral coil of wire traversed by a current acts as an electromagnet (though not so powerfully as when an iron core is placed in it). Such a coil is sometimes termed a solenoid. A solenoid has two poles and a neutral equatorial region. (Ampere found that it will attract magnets and be attracted by magnets.) It will attract another solenoid; it has a magnetic field resembling generally that of a bar magnet. A winding of wire is called a coil. The usual form of coil consists of wire wound on a spool. When the spool is very short and large in diameter the coil is called a circular coil . When a spool is very long in comparison with its diameter the coil is called a solenoid. The solenoid is usually made by winding one or more layers of wire on a long tube.

The magnetic field in a long solenoid is uniform, that is, the field has the same intensity at every point inside of the solenoid and the same direction, namely, parallel to the axis of the solenoid.

Square Mil. A unit of area employed in measuring the areas of cross section of wires, equal to 0.000001 square inch. A unit of area equal to 1.2732 circular mils.

Starting Torque. The turning moment, or force tending to produce rotation, that is required to start a rotating machine. The amount of rotational force that a machine develops while starting.

Step-down Transformer. A transformer in which a small current of comparatively great difference of potential is converted into a large current of comparatively small difference to potential.

Step-up Transformer. A transformer in which a current of comparatively small difference of potential is converted into a smaller current of comparatively great difference of potential.

Storage Battery. A number of separate storage cells connected so as to form a single electric source (see page 343).

Storage Cell. Two relatively inert plates of metals or metallic compounds, immersed in an electrolyte which is incapable of acting on them until an electric current has been passed through the liquid from one plate to the other, and has thus changed their chemical composition. One of the cells required to form a secondary battery. A term sometimes given to a jar containing a single cell.

Synchronism. Unison of frequencies in alternating current systems or apparatus. Generally, the co-periodicity and co-phase of two periodically recurring events. The coincidence in cyclic recurrence of two or more periodic variables, without regard to amplitude.

Three-phase. Pertaining to an alternating current system on which are impressed three, simple, alternating, sine wave e. m. fs., differing in phase by 120 degrees.

Three-phase Transmission. Transmission by means of three-phase currents.

Three-wire System. The three-wire system is usually understood to mean the Edison three-wire system. The outer wires of this system refer to those wires having maximum potential between them and the middle or neutral wire is, for a balanced system, at zero potential; one outer wire, also called the positive wire, having a potential of approximately 110 volts higher and the other outer wire, also called the negative wire, having a potential of 110 volts lower than the neutral.

Torque. The moment of a force applied to a meter or other machine which causes its rotation. The mechanical rotary or turning force which acts on the armature of a dynamo-electric machine, or meter, and causes it to rotate. The ratio of the mechanical activity of a motor, at its belt or pulley, to the angular velocity.

Transformer. A stationary piece of apparatus for transforming, by electromagnetic induction, power from one circuit to another, or for changing, through such transformation, the values of the electromotive force or the current.

Two-phase. Pertaining to an alternating current system on which are impressed two simple, alternating, sine wave e. m. fs., differing in phase by 90 degrees.

Two-wire System. A two-wire system is a system for distributing electrical energy by means of two wires.

Volt. The practical unit of electromotive force. One volt (E) will force one ampere of current (I) through one ohm of resistance (R). Such an electromotic force as is induced in a conductor which cuts lines of magnetic flux at the rate of 100,000,000 per second. Such an electromotive force as would charge a condenser of the capacity of one farad with a quantity of electricity equal to one coulomb.

The International volt, as defined by the Interna-

tional Electrical Congress, which met in Chicago in 1893, "is the electromotive force that, steadily applied to a conductor whose resistance is one International ohm, will produce a current of one International ampere, and which is represented sufficiently well for practical use by $\frac{1,000}{1,434}$ of the electromotive force between the poles of the voltaic cell, known as Clark's cell, at a temperature of 15 degrees C."

Since the Weston cell possessed many advantages over the Clark cell, it was officially adopted in place of the Clark cell as the standard of electromotive force by the London International Electrical Congress of 1908. On January 1, 1911, the U. S. Bureau of Standards adopted a new value for the electromotive force of the Weston normal cell, namely:

$E = 1.01830$ International volts at .20 deg. C.

Voltage. The value of the electromotive force or difference of potential of any part of a circuit, expressed in volts.

Voltage Transformer. A stationary device by which the voltage or potential difference of one alternating current circuit may be changed in a definite ratio, to a voltage or potential difference in a secondary or associated circuit, through the action of electromagnetic induction. See Potential Transformer.

Voltmeter. Any instrument employed for measuring differences of potential.

In the ordinary operation of a voltmeter, the action of the current in passing through a coil of insulated wire is to produce a magnetic field, which causes the deflection of a magnetic needle. Since the resistance of the voltmeter is constant, the current passing, and hence the deflection of the needle will vary with the value of the voltage. The magnetic field produced by the current deflects the magnetic needle against the action of another field, which may be either the earth's field or an artificial field produced by a permanent or electromagnet. Or, it may deflect it against the action of a spring, or against the force of gravity acting on a weight.

Watt. A unit of electrical power. A volt-ampere. The energy contained in a current of one ampere with an electromotive force of one volt. 746 watts = one horse power. The power developed when 44.25 foot-pounds of work are done in a minute, or 0.7375 foot-

pounds of work are done in a second; 1/746 of one horse power.

The International watt is the energy expended per second by an unvarying electrical current of one International ampere under an electric pressure of one International volt.

Watthour. A unit of electrical work or energy. A term employed to indicate the expenditure of electrical energy equivalent to one watt for one hour.

Watthour Meter. A meter for measuring and registering electrical energy in watthours.

Work. When a force acts on a body the product of the force by the distance through which it acts in the direction of the force is called the work performed by the force. Thus when a force applied to a heavy body raises it a certain vertical distance, work is performed by the force, the amount of the work being the product of the force and the distance of ascent; and when a horizontal force draws a body horizontally the work is the product of the force and the horizontal distance. The unit of work is the work done by the unit force in acting through unit distance.

In practical mechanical work the unit of time is always one minute, and the unit which measures the work performed in a given time is the foot-pound per minute. This unit is called the unit of mechanical power.

Power is, therefore, rate of doing work, and hence the power exerted can always be determined by dividing the work done in foot-pounds by the time in minutes required to do it. In practical electrical work the unit of time is the second, and the unit which measures the work performed in a given time is the joule per second. This unit is called the unit of electrical power, and has been named the watt.

The equation or formula expressing the power exerted in any electrical circit is determined as follows: The electrical power is expressed by watts = joules per second; but joules = volt-coulombs, and hence joules per second = volt-coulombs per second. Therefore also, watts = volt-coulombs per second. Now, coulombs per second = amperes. Inserting this value above, watts = volts $\times$ amperes, or $P = EI$.

When the power is to be expressed by the current and resistance, the formula is obtained as follows: According to formula $P = EI$. According to Ohm's

law, $E = IR$. Substituting this value of $E = IR$ in the formula $P = EI$, we have

$$P = I \times I \times R = I^2R$$

When the power is to be expressed by the electromotive force and resistance, the formula is obtained as follows: According to formula, $P = EI$. According to Ohm's law, $I = \frac{E}{R}$. Substituting the value of $I = \frac{E}{R}$ in $P = EI$, we have $P = \frac{E}{R} E = \frac{E^2}{R}$.

Zero Potential. An arbitrary level from which electric potentials are measured. The earth's potential.

ABBREVIATIONS.

The abbreviations used in Standard Wiring are those which have been adopted by the A. I. E. E. for the purpose of shortening names when used in connection with definite numerical values.

Name.	Abbreviation.
Alternating current,	spell out.
Amperes,	spell out.
Ampere-hour,	ampere-hr.
Brake horse power,	b. h. p.
Boiler horse power,	boiler h. p.
British thermal units,	B. t. u.
Candle-power,	c-p.
Centigrade,	Cent.
Centimeters,	cm.
Circular mils,	cir. mils.
Continuous current,	spell out.
Counter electromotive force,	counter e. m. f.
Cubic,	cu.
Diameter,	spell out.
Electrical horse power,	e. h. p.
Electromotive force,	e. m. f.
Fahrenheit,	Fahr.
Feet,	ft.
Foot-pounds,	ft-lb.

Abbreviations (continued)

Name.	Abbreviation.
Hours,	hr.
Inches,	in.
Indicated horse power,	i. h. p.
Kilowatts,	kw.
Kilowatthours,	kwhr.
Minutes,	min.
Ohms,	spell out.
Percentage,	per cent (or % in tabular matter).
Pounds,	lb.
Power-factor,	spell out.
Revolutions per minute,	rev. per min. (or r. p.m.).
Seconds,	sec.
Square,	sq.
Volts,	spell out.
Volt-amperes,	spell out.
Kilovolts,	kv.
Kilovolt-amperes,	kv-a.
Watts,	spell out.
Watthours,	watthr.
Watts per candle-power,	watts per c-p.

USEFUL WIRING FORMULAS.

General Formulas Ohms Laws (Direct Current).

I = current in amperes.
E = electromotive force in volts.
R = resistance in ohms.
W = energy in watts.

$$I = \frac{E}{R} \qquad E = IR \qquad R = \frac{E}{I}$$

$$IE = W \qquad W = \frac{E^2}{R} \qquad I^2R = W$$

$$\frac{W}{746} = \text{H.P.} \qquad W = 746 \times \text{H.P.}$$

Formulas giving the volts or amperes necessary for a given horsepower on direct current circuits:

$$E = \frac{746 \times \text{H.P.}}{I \times K}$$

$$I = \frac{746 \times \text{H.P.}}{E \times K}$$

E = potential of circuit.
I = amperes.
K = efficiency of machine.
H.P. = horsepower.

General Formulas for Direct Current Light and Power Wiring. When possible use the table on page for convenience.

c.m. = circular mils.
d = length of wire, in feet, on one side of circuit.
n = number of lamps in multiple.
i = current in amperes per lamp (see p. 366).
v = volts lost in lines.
r = resistance per foot of wire to be used.
10.8 ohms = resistance of one foot of commercial copper wire having a diameter of one mil and a temperature of 75° Fahrenheit.

It is an easy matter to find any of the above values by the following formulæ for direct current:

$$\text{c.m.} = \frac{10.8 \times 2d \times n \times i}{v}$$

$$\text{c.m.} = \frac{10.8 \times 2d \times n \times i}{} \qquad = \frac{\text{c.m.} \times v}{10.8 \times 2d \times n}$$

$$n = \frac{\text{c.m.} \times v}{10.8 \times 2d \times i} \qquad 2d. = \frac{\text{c.m.} \times v}{10.8 \times i \times n}$$

$$r = \frac{v}{n \times i \times 2d}$$

$$v = n \times i \times 2d \times r \qquad i = \frac{v}{2d \times n \times r}$$

$$n = \frac{v}{i \times 2d \times r} \qquad 2d = \frac{v}{n \times i \times r}$$

USEFUL MECHANICAL FORMULAS

Belting for Various Purposes

Open belting: $L = \frac{\pi}{2} S + 2C \left(1 + \frac{1}{8} \frac{D^2}{C^2} \right)$

L = Length of belt.
S = Sum of pulley diameters.
C = Distance between centers of pulleys.
D = Difference of pulley diameters.
π = 3.141592, or, for practical purposes, 3.1416.

For calculating the length of belting approximately, add one-half the circumference of each pulley to twice the distance between centers of the pulleys.

To find the horsepower strength of double leather belting when:

d = diameter of small pulley in inches.
r = revolutions of small pulley per minute.
b = breadth of belting in inches.
H. P. = horsepower to be transmitted.

$$\text{H. P.} = \frac{d \times r \times b}{1925}$$

"Double" belting is expected to transmit twice as much power as "single" belting, and "light double" one and one-half times that of "single."

$$d = \sqrt[3]{\frac{50 \text{ h. p.}}{R}} \text{ for bare shafts, or H. P.} = \frac{Rd^3}{50}$$

Red Devil
Pliers No. 4950

Red Devil

REG. U.S. PAT. OFF.

Pliers No. 4950

Red Devil
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stands for a long line of Electrician's tools, honestly made, honestly priced and honestly advertised.

Catalog on request.

SMITH & HEMENWAY CO., Inc.

119 Coit Street, Irvington, N. J.

or $d = \sqrt[3]{\frac{70 \text{ h. p.}}{R}}$ for shafts carrying pulleys, etc.

or $\text{H. P.} = \frac{Rd^3}{70}$

$l = \sqrt[3]{720\ d^2}$ for bare shafts, or $d = \sqrt{\frac{l^3}{720}}$

or $l = \sqrt[3]{140\ d^2}$ for shafts carrying pulleys, etc.

or $d = \sqrt{\frac{l^3}{140}}$

H. P. = horse-power transmitted.
d = diameter shaft in inches.
R = revolutions per minute.
l = length between supports in feet.

Horse-power of Engines

H. P. = indicated horse-power.
Ps = travel of piston in feet per minute.
A = area of piston in square inches.
M. E. P. = mean effective pressure in pounds per square inch.
Ip = initial pressure.

and:

(a) $\text{M. E. P.} = \frac{34 \times \text{Ip}}{57}$ at ¼ cut off

(b) $\text{M. E. P.} = \frac{11 \times \text{Ip}}{13}$ at ½ cut off

An application of these formulæ in an appropriate example may be considered in the following problem:

It is desired to determine the I. H. P. of an engine whose cylinder is 10 inches in diameter and whose stroke is 12 inches, operating at 300 revolutions per minute, the initial steam pressure being 100 pounds per square inch, cutting off at one-quarter and one-half stroke, respectively.

$$\text{(a) M. E. P.} = \frac{34 \times Ip}{57} = \frac{34 \times 100}{57} = 59.65 \text{ at } \tfrac{1}{4} \text{ cut off.}$$

$$\text{(b) M. E. P.} = \frac{11 \times Ip}{13} = \frac{34 \times 100}{13} = 84.6 \text{ at } \tfrac{1}{2} \text{ cut off.}$$

$$A = \frac{\pi}{4} \times \text{diameter}^2 = .7854 \times 10^2 = 78.54 \text{ square inches.}$$

Ps = .2 feet per revolution and 30 revolutions per minue = 600 feet per minute.

$$\text{I. H. P. at } \tfrac{1}{4} \text{ cut off} = \frac{Ps \times A \times \text{M. E. P.}}{33{,}000} =$$

$$\frac{600 \times 78.54 \times 59.65}{33{,}000} = 85.18$$

$$\text{I. H. P. at } \tfrac{1}{2} \text{ cut off} = \frac{Ps \times A \times \text{M. E. P.}}{33{,}000} =$$

$$\frac{600 \times 78.54 \times 84.6}{33{,}000} = 120.8$$

Data on Pulleys and Gears

For single reduction or increase of speed by means of belting where the speed at which each shaft should run is known, and one pulley is in place:

Multiply the diameter of the known pulley by the number of revolutions per minute that its shaft makes; divide this product by the speed in R. P. M. at which the second shaft should run. The result is the diameter of pulley to use.

Where both shafts with pulleys are in operation and the speed of one is known:

Multiply the speed of one shaft by diameter of its pulley and divide this product by diameter of pulley on the other shaft. The result is the speed of the second shaft.

Where a countershaft is used, to obtain size of main driving or driven pulley, or speed of main driving or driven shaft, it is necessary to calculate, as above, between the known end of the transmission and the countershaft, then repeat this calculation between the countershaft and the unknown end.

A set of gears of the same pitch transmits speeds in

proportion to the number of teeth in each. Count the number of teeth in the gear wheel and use this quantity instead of the diameter of pulley, mentioned above, to obtain number of teeth in unknown gear or speed of second shaft.

Formulas for Finding Size of Pulleys.

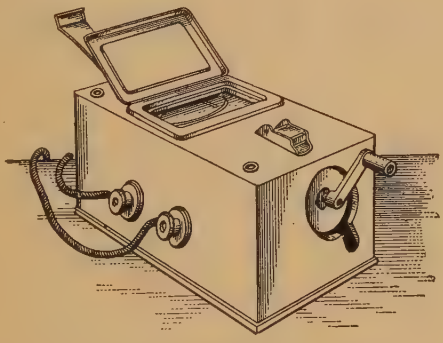
$$d = \frac{D \times S}{S'} \qquad D = \frac{d \times S'}{S}$$

d = diameter of driven pulley.
D = diameter of driving pulley.
S = number of revolutions per minute of driving pulley.
S′ = number of revolutions per minute of driven pulley.

To find the speed of the belt in feet per minute, multiply the circumference of the pulley in feet by the number of revolutions per minute. For best results, the belt speed should be from 3,500 to 4,500 feet per minute.

MEASURING RESISTANCE

It is frequently necessary to know just what the insulation resistance of a line, or the wiring in a building, is in ohms.



The "Megger" for Measuring Resistance.

Heretofore such tests have been made with some form of portable testing set (Wheatstone Bridge), or by the voltmeter method, inconvenient calculations being necessary in either case.

Now, however, there is on the market an instrument,

Test the Insulation Resistance of INTERIOR WIRING With a

MEGGER

It reads in ohms (no calculations being required); and is equipped—in the same case—with a hand-driven generator, that supplies direct current of 100 volts or more, depending upon capacity of the instrument.

Hundreds of Meggers are in service—and we strongly recommend them to the attention of Fire Underwriters, Inspectors, Operating Engineers and Contractors.

Our "Megger-method" is approved and largely used by the U. S. Government.

Write for Pamphlet 847,
"A Stitch in Time."

JAMES G. BIDDLE

Electrical Measuring Instruments
1211-13 ARCH STREET, PHILADELPHIA

called the Megger, by means of which conductor or insulation resistance can be measured as quickly and as accurately as voltage is measured with a voltmeter. A small hand generator is mounted in the case, so that no outside source of current is required.

Tests by the "Megger-method" are made as follows: connect a wire from one side of the circuit to binding post of the Megger marked "Line," and with another piece of wire connect a water pipe to the "earth" binding post of the Megger. Turn the generator handle at one end of the Megger case, and the pointer of the instrument will instantly show the correct resistance—the scale being graduated in ohms.

As the generator voltage is usually 100 or 250 volts, there is the added advantage that tests by the "Megger-method" are practically made under working conditions.

SOLDERING

All wires and cables when joined or spliced should be mechanically and electrically secure without the use of solder. The joints should then be soldered, unless made with some form of approved splicing device, and covered with an insulation equal to that on the conductors. Stranded wires, except in flexible cords, should be soldered before being fastened under clamps or bringing screws, and whether stranded or solid, when they have a conductivity greater than that of No. 8 B. & S. gage they should be soldered into lugs for all terminal connections, except where an approved solderless terminal connector is used.

A few useful pointers on the art of soldering—and soldering is an art—are as follows:

There are but four essential principles, and when these are followed, anyone can, after a little practice, do as good work as the most experienced workman.

The four principles of soldering are as follows:

(1) The soldering iron (it is called an "iron" but in reality it is solid copper) must be kept clean and well tinned.

(2) A good non-corrosive soldering flux must be used.

(3) The metals to be soldered must be thoroughly cleaned, before the joint is made, by scraping, or filing or the use of emery paper.

ALLEN FLUX

Non Acid Sodering Flux.

"It's all in the Flux"

And ALLEN Fluxes insure strong, safe, enduring joints

Why are ALLEN NON-ACID SODERING FLUXES approved by the National Board of Fire Underwriters?

Why have the dominant electrical industries of the country adopted Allen Fluxes for their own work—in shop and in field?

Isn't it because both the National Board and the Big Business have satisfied themselves by extended and exhaustive laboratory tests and by daily practice that Allen Fluxes live up to our claims of insuring:—

(1) The strongest sodered joints

(2) Greatest protection against corrosion

Write us for samples and prices on:

ALLEN Sodering Stick
ALLEN Sodering Paste
ALLEN Sodering Liquid
ALLEN Sodering Salts
ALLEN Alumi-flux
ALLEN Alumi-soder

Put all these products to the severest test your ingenuity and experience can suggest, side by side with whatever other fluxes you believe to have merit.

No Joint is Stronger than its Flux

Get in touch with us on all your sodering problems

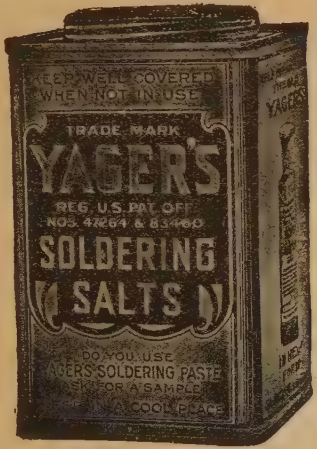
at it since '93

L. B. ALLEN CO,, Inc.

4582 No. LINCOLN STREET
CHICAGO, ILL.

YAGER'S SOLDERING FLUXES

For 47 Years Yager's Fluxes have stood the Test



Yager's Soldering Fluxes prove their own claims.

First on the market forty-seven years ago—and still first. Make joints stronger than the original metals; non-acid, and non-corrosive. Fine fluxes for fine work—irons remain tinned longer—solder goes where you want it, and STAYS there—little goes far. Let us prove it to YOU.

SALTS

The original dry salt flux, twice improved, in our new enameled tin container. Packed in tin? Of course; it is NON-acid.

In ½, 1 and 5 lb. cans; in bulk, 100 lb. kegs, if you wish.

FLUID.—A highly concentrated fluid form of the Salt flux for those desiring that kind. In 1-gal. cans only.

PASTE.—The latest paste formula, containing all the elements of the Salts in paste form, and then some. Handy for the kit; adapted to every use of the electrician, switchboard, cable, commutator windings, anything, anywhere; a strong joint, with no short circuits and no leakage. In 2-oz., 8-oz., 1 and 5-lb. tins, or 50-lb. tubs.

Ask Your Jobber for Prices

ALEX. R. BENSON COMPANY, Inc.

HUDSON, N. Y.

(4) The joint must be heated above the melting point of the solder.

Soldering requires heat.

You may use a gas stove, coal stove, or a gasoline torch. Any of these will work satisfactorily. For small splices the iron is not used, the flame of the torch being applied directly to the splice.

Soldering irons cannot be heated properly in the yellow or illuminating flame of the gas because it smokes the soldering iron, and also because it is not hot enough.

It needs a blue flame, the same as given off by a gas stove, but a good clean coal fire will do.

To tell when the soldering iron is hot enough, try it by putting the solder to the point, If the solder melts as soon as it touches the iron it is hot enough and ready to use. If the iron is overheated the tinning will be burned off and it must be retinned, or if the end of the iron becomes black and the black will not wipe off the iron needs retinning.

To retin a soldering iron if the tinning gets burned off, rub it on a clean brick, sand paper, emery cloth, or file to brighten the surfaces, and if it is badly pitted file it smooth.

Then heat it by any of the methods suggested and put on a suitable soldering flux, rubbing on the solder, at the same time going over all four sides of the iron while it is still hot, and wipe them on an old cloth.

This makes the soldering point of the "iron" look bright and shiny, the color of new tin.

Your soldering iron must be kept in this condition if you wish to do good work, and the cleaner and better the iron is kept, the better the class of work you will be able to do.

For ordinary work the flux should be in the form of a paste, which can be applied with a stick or a brush, or the end of the solder.

If it can be done, the best results will be obtained by holding the hot soldering iron underneath the parts to be soldered, remembering that both sides of the joint to be soldered must be heated alike to make a good joint.

The solder is then held on the top, and as the heat rises it melts the flux, which should flow to every part of the joint, and later the solder melts and flows as far as the flux, making a perfect joint.

Where it is impossible to apply the heat from below, good work can be obtained by keeping the iron on

THE STANDARD—

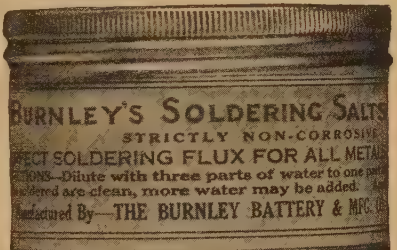
SOLDERING PASTE, STICK AND SALTS

—FOR TWENTY-ONE YEARS

Get the flux that sticks to the job. Free from acids and is always ready for use. Makes solder flow evenly and smoothly—stays put.

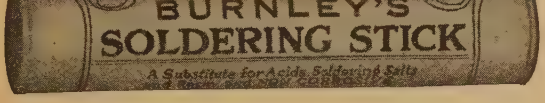
LOOK FOR THE YELLOW LABEL

If you prefer a liquid flux use one part Burnley Soldering Salts to six parts of water and apply with a brush. It is the best of its kind made for all work.


BURNLEY'S SOLDERING SALTS
STRICTLY NON-CORROSIVE
ECT SOLDERING FLUX FOR ALL METAL
TIONS—Dilute with three parts of water to one part
dered are clean, more water may be added.
ufactured By—THE BURNLEY BATTERY & MFG. CO.

½ and 1 Pound Screw Top Cans

SEND FOR LARGE FREE SAMPLE



5½ Inches Long and 1 Inch Diameter

Rub Burnley's Soldering Stick on the heated joint, then the solder and flame. No better soldered joint can be made.

BURNLEY, BATTERY & MFG. CO.

NORTH EAST, PA.

New York Chicago Buffalo Los Angeles
Minneapolis Duluth Toledo Charlotte Bay City

throw away your soldering acid!

Don't use Sal Ammoniac or other acid for a dip to brighten your iron; they eat up the tinning, and corrode the work.

Dissolve ONE pound of Nokorode Salts in one GALLON of distilled water; use this solution as a dip to clean and to tin the iron, as well as to flux the work, and you will get better work at less cost.

NOKORODE

SOLDERING PASTE AND SALTS

helped win the war. Used by U. S. Government here and "Over There", and exclusively on the telephone circuits of the Panama Canal; by 90% of the Electrical trade of the country; by the leading Aeroplane makers; all the big automobile manufacturers in America, and by the largest food packers.

WRITE FOR

"SOLDERING KINKS"

a practical manual of soldering; simple enough for beginners, thorough enough for real mechanics. Fully diagrammed and illustrated. New and practical solutions of difficult soldering problems by experienced mechanics and experts all over the country. Price, 25 Cents. Prepaid anywhere in the U. S. A. Send for your copy.

THE M. W. DUNTON CO., Providence, R. I. U. S. A.

top, provided you are careful to get the parts to be soldered hotter than the melting point of the solder.

When the solder has run freely take the soldering iron away and let the parts soldered get cold.

Where there is no danger in setting fire to adjacent objects the soldering torch does the quickest and best work, and for outside or pole line work it is indispensable.

If the joint is given a slight tap while the solder is still hot the surplus will be shaken off and a clean-looking joint will be the result.

If the solder looks bunchy, while it is still warm take a cloth with a little of the flux on it and rub it over quickly. This will make a clean, smooth joint.

If acid is used, and it should be avoided if possible, wipe the joint thoroughly after soldering and before applying the insulating tape, covering or sleeve.

LIGHTNING ROD PROTECTION

As many readers of this book—the contractors and wiremen throughout the county—are frequently called upon to give advice regarding the installation of lightning rods, and even called upon to do the work of installing them in connection with their other work, it seems important to devote a section in the edition on this important subject.

Nation-wide statistics, collected and preserved by insurance companies, have proved conclusively that a proper and adequate installation of lightning rods, especially in outlying districts, have been the means of saving thousands of dollars in the prevention of loss by lightning discharge.

In one report from a number of insurance companies in one section of the country it was shown that out of 7,000 **unrodded** buildings, 37 were struck by lightning with varying losses, while in every 7,000 **rodded** ones only two were struck by lightning, and it is quite possible that the two buildings thus damaged were improperly rodded.

These few facts, which are all matters of record in published reports, establish beyond question the conclusion given, that if all buildings were rodded 95 per cent. of the annual lightning damage would be eliminated.

DODD & STRUTHERS

DES MOINES, IOWA

Manufacturers

The Dodd System of Lightning Protection

Recognized universally as the standard in construction and installation.

Special equipment for smoke stacks, fine residences, factories and other special or difficult jobs.

Write for any information you may desire

Kind of Rods. Copper rods are the most durable, and therefore the best, and cheapest in the end, although any metal will do the work as long as in proper condition. But iron rusts off at the ground, and aluminum also corrodes under certain conditions. A rod composed of two different metals, one wrapped around the other, is especially objectionable.

How to Install Lightning Rods

The following specifications outline the best known practice and offer a practical and economical solution of the problem.

Grounding. As the foundation of a building is the most important part of the structure, so the grounding of a lightning rod system is the most important part of the system. It has been said by some scientists that a poor ground creates a hazard when a lightning rod is connected to it. While this is not to be taken without salt, yet it goes to show that this feature of the installation cannot be taken too seriously.

Furthermore, the grounding should be known to be properly done at the time of installation, for it can never be inspected afterwards, without digging up the grounds.

There are two good methods of grounding covered under A and B, as follows, and the one most suitable should be chosen when the nature of the soil is known.

Method A—Attaching the Ground Wire to a Water Pipe. This method is to be preferred in all cases. The connection to the water pipe should be made at a point outside the building.

Connection to piping to be made preferably by soldering the conductor into a brass plug and forcibly screwing the plug into the pipe fitting, or, when the pipes are cast-iron, into a hole tapped into the pipe itself, or by sweating the conductor into a lug attached to an approved clamp and firmly bolting the clamp to the pipe after the result and scales have been removed.

The idea is to get as good and permanent connection to the underground piping as possible, and one that will best withstand the effects of corrosion. It is desirable to connect to two or more lengths of pipe in order to guard against crippling the protection by injury to or deterioration of a single connection.

Method B—Extending the Rod Into the Ground to Moist Earth. This method may be used only where the earth is permanently moist up to within a few feet of the top of the ground and the rod should extend at least 10 feet into the ground.

Shinn-Flat

Lightning Rods
Prevent Lightning Losses

Shinn-Flat is the one scientifically designed and constructed conductor that is guaranteed to prevent Lightning damage.

36% Greater Protection

Shinn-Flat Conductors are made of fine copper wires, woven flat, and have 36% more conducting surface than any round rod or cable containing an equal amount of material.

Shinn-Flat is Bonded to Protect

Every Shinn-Flat installation is covered by a Cash Bond that Lightning will not strike, paid for by us and issued direct to you by a large independent Bonding Company. The W. C. Shinn Mfg. Company is the only manufacturer of Lightning Conductors that ever backed up its goods and its work in this practical way.

Every building should be protected and the Electrical Contractor is the logical man to install such protection. We teach you how to properly protect any building, and co-operate with you in getting the business. Write us for particulars.

W. C. SHINN MFG. COMPANY

14 E. Jackson Blvd. CHICAGO, ILL.

It is sometimes desirable to dig a trench, as, for instance, there is a hard pan or rock near the top of the ground, at least 12 feet long and as deep as possible and lay the rod in the bottom.

This method will give good results in clay soil.

Number of Ground Connections. There should be no less than four ground connections on any building, one at each corner of a square or oblong building.

An L-shaped building may require at least five and a T-shaped building at least six ground connections.

Conductors (all conductors are commonly spoken of as rods). The conductors or rods should be of copper, weighing not less than three ounces per foot. The rods should be loosely woven or stranded in such a manner that there will be considerable "give and take" so that they will not be misplaced by the settling of the building when loaded.

The rods should be carried from the peak to the eaves of the building, then down the sides to the groundings and should never be carried over the cornice at any point except at eaves.

The metal eave spouts and down spouts as well as metal ridge should be fastened to the rods by a soldered connection.

The upper horizontal conductor should be carried along the most exposed part of the roof as that is where the lightning is most liable to strike when not protected.

Air Terminals. The air terminals are the pointed elevations extending from the conductor into the air. They should in general be located not more than 25 feet apart, and, in addition, upon all high or prominent parts of the roof such as cupolas, chimneys, texas of mill or elevator, ventilators, etc. The main points to be observed in choosing the air terminals are substantial construction with features provided for making good, permanent, connection to the rod and solid fastening to the roof.

Metal in the Building. Metal apparatus, such as piping (other than gas piping), metal water tanks in the attic, etc., should be connected to the conductor. The connection to the conductor should be made as near the roof as possible, and the lower end grounded if the run is vertical.

General. (a) Rods should not be insulated from the building.

(b) as few joints as possible should be used, and all joints should be made electrically and mechanically secure and protected from corrosion.

(c) The rods should run in as near a direct line as possible, avoiding sharp bends and inclining downward. They should never run through iron pipes.

Summary

As an Industry the Lightning Rod business has been in the past very much misunderstood as to the value of the work done in saving buildings from destruction by fire and damage as a result of lightning stroke.

Perhaps more research work definitely placing a value on this Industry has been done during the past ten years than ever before. State Fire Marshals, the Engineering Departments of Agricultural Colleges, and other authorities on fire protection, as well as the Editors of national farm papers, endorse and encourage the use of standard systems of lightning prevention.

The United States Bureau of Standards in 1914, after an exhaustive research conducted by their most able physicists, published a very important bulletin, Technologic Papers No. 56, which may be had from the Bureau of Printing, Washington, D. C., at 35c per copy.

The United States Weather Bureau, Washington, D. C., annually issues important bulletins on lightning protection and, indeed, both of the above departments highly recommend the use of standard lightning rods.

The Underwriters' Laboratories of Chicago, Ill., have approved certain types, and admitted these to label service. In fact, all authorities agree that buildings can be made immune from lightning damage by installing in a scientific and workmanlike manner high-grade systems of Copper Cable Lightning Rods.

The growth of this Industry has advanced to meet the demand of property owners who have realized that without lightning rods their many thousands of dollars worth of buildings would not be safe from fire, during seasonal storms, and that Fire Insurance would not protect them from loss. Several legitimate, high-class manufacturers today supply a big number of responsible dealers throughout the United States.

Such manufacturers support their advertised claims with cash indemnity bonds, and guarantees; hence, the retail customer is fully protected in his investment, as these companies train their sales organizations and dealers in properly protecting buildings.

It is essential today that the manufacturer be known for his many years integrity in this industry; then any dealer is safe as an exclusive licensed representative in selling his product.

Advantages of Transformer Bells

The use of specially constructed transformer bells made for use in connection with bell ringing transformers have the great advantage in this system over the ordinary dry battery system in that such an installation is practically permanent for all time, and if installed in accordance with the Underwriter's rules for bell ringing transformers make the safest and most dependable system for this class of annunciator work. The most disagreeable feature in connection with the dry battery system is the giving out of the dry battery at just the time when it is most needed.

The cost of a good bell ringing transformer, together with the specially constructed bells for use in such a system, is cheaper in the long run than any other system. For years it was considered impossible to obtain satisfactory results for large bells on low voltage alternating current for the reason that the ordinary battery bell would not answer because the solid cores retained the magnetism too long and the armature did not respond quickly to the cycle changes. The laminated cores, which are now being used by the best manufacturers of transformer bells, have eliminated this difficulty.

The readers of this book, in purchasing bells, for use on bell ringing transformer systems, should secure them from the manufacturers who have made a specialty of this class of bell. When installing such a system of electric bells operated by transformers, it is a safe rule to allow 6 to 8 watts per bell for sizes of from 5 to 12 inches and 3 watts each for 3 and 4 inch bells and buzzers.

Bell ringing transformer (average approved type) will ring up to 4 bells, size 3 or 4 inches, or buzzers or 1 bell sizes 5 to 12 inches.

EDWARDS
TRANSFORMER BELLS

SELL and install Edwards Transformer Bells. It means good business for you—and perfect bell-ringing service for your customers. Should be used wherever a signal is to be operated on alternating current, or when a number of bells of any size are to be operated simultaneously. Edwards Bells are the only bells of large size that will operate satisfactorily on transformers of low wattage. They are the result of fifty years of specialization in this field. Write for catalog showing the complete line.

EDWARDS & COMPANY, Inc.

CHICAGO
Monadnock Block

NEW YORK
140th & Exterior Sts.

ATLANTA
29 Poplar St.

Northern Electric Company

LIMITED
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RESUSCITATION FROM ELECTRIC SHOCK

As recommended by The National Electric Light Association. Follow these instructions even if the victim appears dead.

I. Immediately Break the Circuit

With a single quick motion, free the victim from the

FIG. 1—INSPIRATION; PRESSURE OFF.

current. Use any **dry non-conductor** (clothing, rope, board) to move either the victim or the wire. Beware of using metal or any moist material. While freeing the victim from the live conductor have every effort also made to shut off the current quickly.

II. Instantly Attend to the Victim's Breathing

As soon as the victim is clear of the conductor, rapidly feel with your finger in his mouth and throat and remove any foreign body (tobacco, false teeth). Then begin artificial respiration at once. Do not stop to loosen the victim's clothing now; every moment of delay is serious. Proceed as follows:

(a) Lay the subject on his belly, with arms extended as straight forward as possible and with face to one side, so that nose and mouth are free for breathing (see Fig. 1). Let an assistant draw forward the subject's tongue.

(b) Kneel straddling the subject's thighs, and facing his head; rest the palms of your hands on the loins (on the muscles of the small of the back), with fingers spread over the lowest ribs, as in Fig. 1.

(c) With arms held straight, swing forward slowly so that the weight of your body is gradually but **not violently,** brought to bear upon the subject (see Fig. 2). This act should take from two to three seconds.

(d) Then immediately swing backward so as to remove the pressure, thus returning to the position shown in Fig. 1.

(e) Repeat deliberately twelve to fifteen times a minute the swinging forward and back—a complete respiration in four or five seconds.

(f) As soon as this artificial respiration has been started, and while it is being continued, an assistant should loosen any tight clothing about the subject's neck, chest, or waist.

FIG. 2—EXPIRATION; PRESSURE ON.

2. Continue the artificial respiration (if necessary, two hours or longer), **without interruption** until natural breathing is restored, or until a physician arrives. If natural breathing stops after being restored, use artificial respiration again.

3. **Do not give any liquid by mouth until the subject is fully conscious.**

4. Give the subject fresh air, but keep him warm.

III. Send for Nearest Doctor

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This edition has been completely revised from the first to the last page and should you notice any error, typographical or otherwise, that may have escaped my notice, you will confer a great favor by calling my attention to same. Any suggestions that you think would improve future editions will be greatly appreciated.

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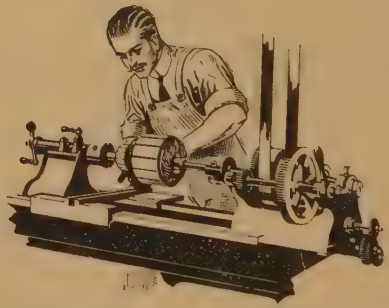

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